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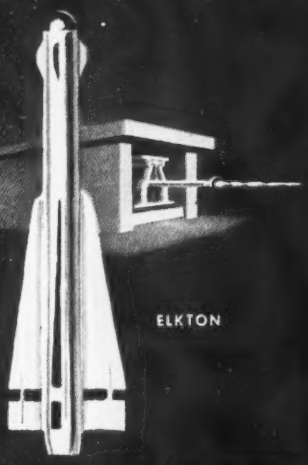
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

JUNE 1959

MAN IN SPACE—
ENGINEERING PROBLEMS

Radio Guidance of Space Vehicles . . . . . Earle B. Mullen
Techniques for Space Vehicle Recovery . . . . . Harold V. Hawkins
From My Life . . . . . Hermann Oberth



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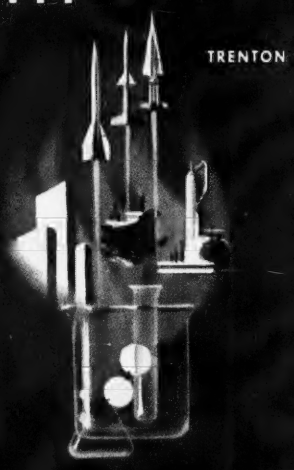

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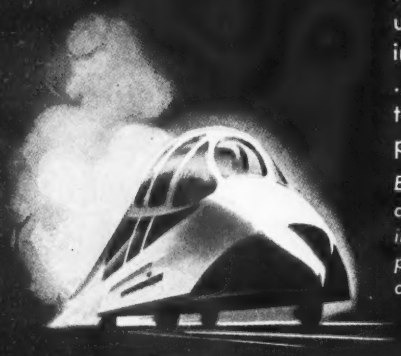

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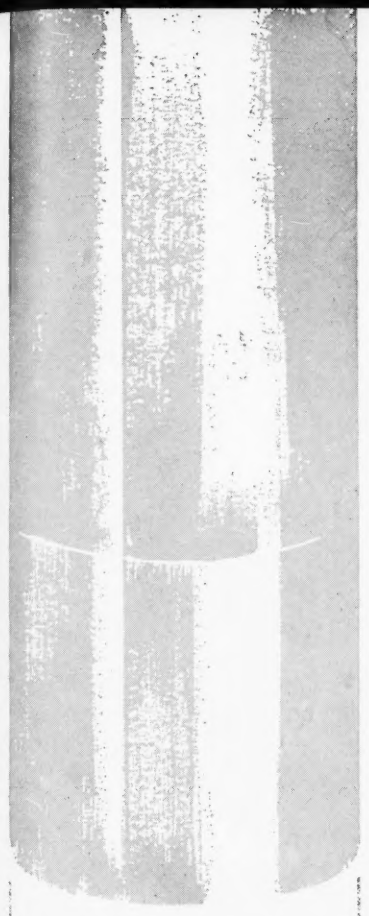

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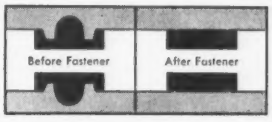

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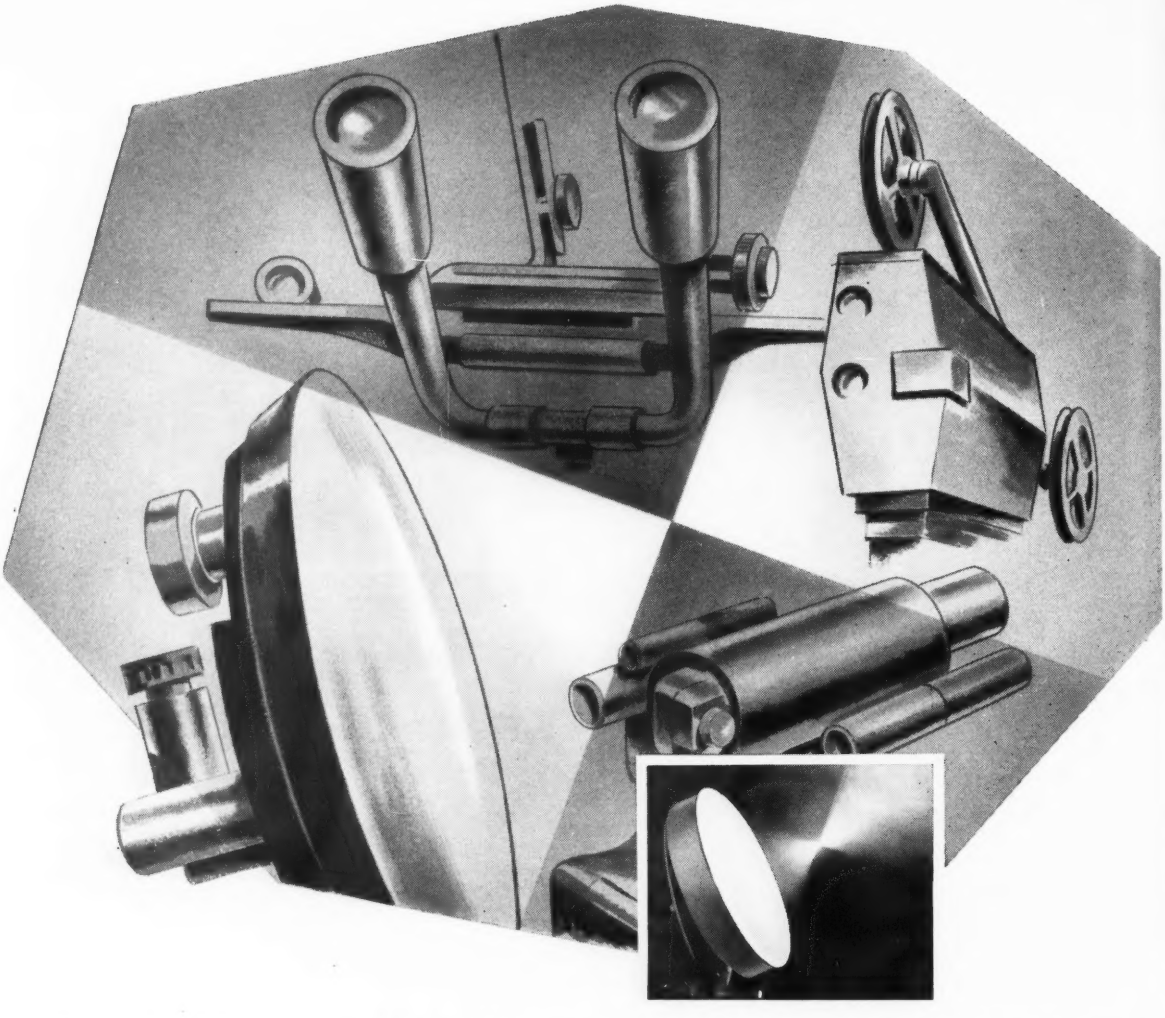

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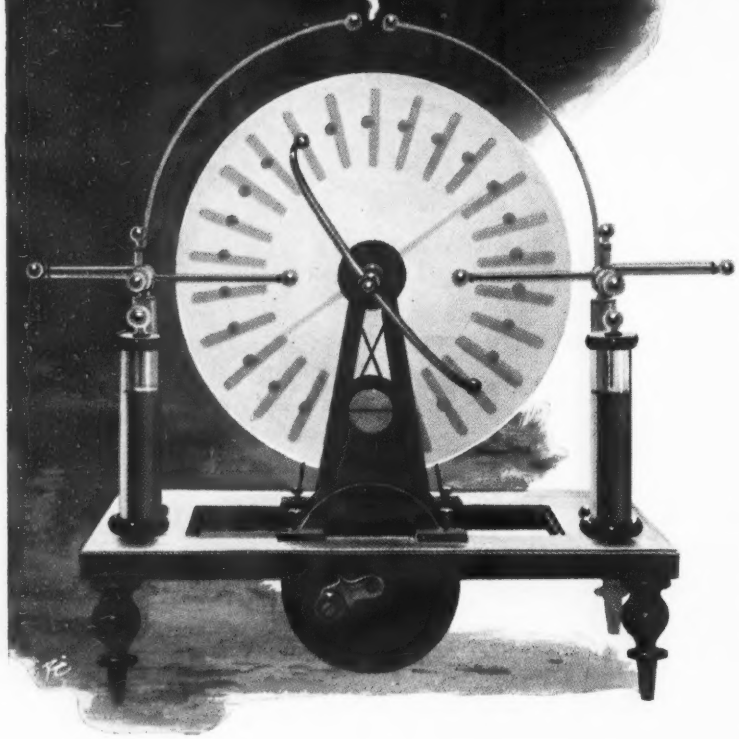
what is charge?



Earth's attraction for a lightning bolt?

+ or −, which is up?

A resonant phenomenon?

A singularity in a field?

What is the nuclear "glue" for like charges?

A better comprehension of charge is important to Allison because energy conversion is our business and charge is one keystone for this conversion work. Thus we have a deep and continuing interest in electrons, protons, positrons, neutrons, neutrinos—charge in all its forms.

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For the record

The month's news in review

April **2**—President Eisenhower chooses Maj. Gen. Bernard A. Schriever, chief of AFBMD, to become new head of ARDC and for promotion to lieutenant-general.

April **3**—AF successfully test-fires a Titan. Bold Orion rocket is launched from a B-47 and a Jupiter is fired 1500 miles down range from Cape Canaveral.

April **4**—AF weighs production of new 1000-mile air-launched ballistic missile, and doubling Atlas orders.

—New satellite tracking range is set up on Long Island, N.Y., as part of Volunteer Satellite Tracking Program.

April **6**—NASA announces selection of 7 military test pilots from among whom the Project Mercury Astronaut will be chosen.

April **7**—First operational AF Snark hits bullseye in 5000-mile test.

—First conversion of nuclear reactor heat directly into electricity by means of a "plasma thermocouple" is announced by AEC's Los Alamos Scientific Lab, presaging long-range potentialities in all atomic power fields, including space propulsion.

April **8**—AF reveals recovery of ceramic nose cone—having newly designed warhead protector—after 5000-mile shot.

—NASA outlines long-range space program to Senate space subcommittee, calling for 1959, launching of eight satellites and two deep space probes, and firing of about 50 sounding rockets; and in 1960, six satellites and four deep space probes, and 90–100 sounding rockets.

—Navy gets DOD nod to proceed with construction of three more Polaris subs.

April **9**—AF reveals recent test-firing of a rocket engine with more than 1 million lb of thrust.

April **12**— NASA plans to launch paddle-wheeled satellite, weighing about 70 lb, in a first step toward exploring Venus, are revealed.

April **13**—U.S. attempt to launch three satellites in one day—two simultaneously from a single rocket—is balked when Navy's Vanguard (containing the double satellites) fails. However, AF places Discoverer II into polar orbit.

—J. B. Macauley, deputy director of defense research and engineering, reveals military is working on a flying saucer project.

—Rep. Victor L. Anfuso (D., N.Y.) introduces a bill providing a tax-free $100,000 prize to first American astronaut.

April **14**—AF destroys Atlas 15 sec after firing.

—AF abandons plan to catch Discoverer II's instrument capsule in mid-air.

April **15**—DOD says Discoverer II's capsule has fallen somewhere in the Arctic region.

April **16**—Sec'y of Commerce Lewis L. Strauss voices opposition to creation of a new Cabinet-level Dept. of Science and Technology.

April **19**—AEC agrees to build large plutonium-producing reactor at Hanford, Wash.

April **20**—U.S. and Canada announce cooperative space research program.

—Navy Polaris makes successful flight.

—Minister of Supply Aubrey Jones indicates Great Britain is once again considering its own earth satellite program.

April **23**—Navy claims development of advanced sonar equipment able to penetrate a sub's defenses.

April **24**—Lt. Gen. B. A. Schriever tells Senate subcommittee AF is working on anti-satellite weapon system.

April **26**—Prof. G. V. Petrovich, writing in official organ of Soviet Academy of Sciences, says Soviet Union plans surveillance satellites.

April **27**—Soviet Union threatens to boycott Committee on Space Research (COSPAR) unless make-up of Committee is changed. Similar objections had been voiced previously regarding UN Committee on Peaceful Uses of Outer Space.

It's a Laboratory

Under this 80 by 20 ft nylon and plastic tent, pitched in the midst of Lockheed's Georgia Div. plant at Marietta, engineers work in a dust-free atmosphere on fabrication techniques for the fuselage of the USAF B-70 supersonic bomber.

Astro notes

SPACE PROJECTS

• NASA promptly began backing programs presented to Congress earlier in the year with dollars, naming Convair-Astronautics prime contractor for Vega with a $33.5 million contract not including cost of Atlas boosters; Douglas prime for Delta with a $24,067,500 contract; and Chance-Vought integrator of Scout with a $945,000 contract. NASA plans now call for eight Vegas, the first to be ready for flight testing by late 1960. A dozen Deltas, much like the three-stage Thor-Able, and capable of putting 250 lb in a nominal 300-mile orbit, will be made available over the next two years. Initial Scout payload tests will come in mid-1960.

• "Engineering problems" with both the payloads and the booster system led NASA to postpone the elongated (30,000 mile) orbit earth satellite and the two probes to be fired in the general direction of Venus this month. The satellite was to test instruments for the two deep space probes.

• ARDC is evaluating proposals for a million-pound-thrust solid-propellant do-all space booster submitted by Aerojet-General, Thiokol, United Research, Allegany Ballistics Lab, Grand Central Rocket, and Astrodyne. ARDC will receive interim reports on planning a military lunar base (Study 192) this summer.

• NASA's new budget (see page 40) includes funds to study robot-armed rocket vehicles for making soft landings on the moon and a permanent manned satellite laboratory the size of a small house. Development of a controllable thrust engine for soft moon landings is imminent.

• In a symposium sponsored by Brooklyn Poly's Microwave Research Institute, K. M. Siegel of the Univ. of Michigan said radar study of the moon indicates that a material like sand or pumice makes up the greater part of the lunar surface. Michigan has proposed to NASA a radar-equipped lunar satellite that would scan the moon's surface at various wavelengths to determine its power reflection coefficient, a measure of material and surface depth. Data would be telemetered to earth.

• DOD research chief Herbert York and JPL director William Pickering both expect the U.S. to be able to place a man on the moon in five years. Dr. York commented that currently available guidance systems, used with the powerful boosters now under development, can direct a manned vehicle to a fairly small area on the moon.

• The first country to install a permanent satellite network for global television may well decide future language dominance of the world. This thoughtful comment was made recently by Duncan MacDonald, vice-president of Itek, perhaps in memory of WW II Coca Cola advertising.

MAN IN SPACE

• The joint working group on Mercury recovery formed by NASA and DOD has Edmond C. Buckley, NASA Asst. Director for Space Flight Operations, and Admiral J. W. Gannon, Asst. Chief of Naval Operations, as co-chairmen. Ship search and recovery of the Mercury capsule are already under study, as present plans call for the capsule landing in the Atlantic.

• Means of recovering the Mercury capsule was the subject of a full-scale conference at Patrick AFB late in April. Blimps, long-duration helicopters, and radar picket planes, with ship support, will be used for sea recovery.

• McDonnell has subcontracted development of the Mercury recovery system to Northrop's Radioplane Div.

• Parachutes for the Mercury program have been tested with the Cree (see page 25) in firings conducted by the Air Force for NASA at the Eglin AFB Santa Rosa center. Cook Electric manufactures the vehicle.

• At the 30th annual meeting of the Aerospace Medical Assn., AF scientist R. J. Hock of the Arctic Aeromedical Lab proposed that space pilots hibernate to keep food consumption down on long trips. His group is conducting a series of experiments along these lines.

• Walter Reed scientists believe that the chemicals mercattoethylamine and cysteine, in combination, may give space pilots a degree of internal immunity from radiation damage. The chemicals have protected dogs from normally lethal doses of radiation.

• MIT's Dept. of Food Technology now has an AF-sponsored program on the production of high energy foods for spacecraft, including the generation of food in a closed ecological system.

• The AF School of Aviation Medicine will have its two-man space training capsule, developed by Minneapolis-Honeywell, delivered to its new home at Brooks AFB this fall. The cabin will be able to sustain two men as long as 30 days.

SATELLITES

• As announced at the ARS Controllable Satellites Conference (see page 58), four white mice are scheduled to be sent into orbit in a Discoverer satellite. An attempt will be made to return the mice with Discoverer's re-entry capsule.

• Meanwhile, the Army announced that it plans to launch an animal (presumably a monkey) over a ballistic trajectory with a Jupiter and attempt nose cone recovery some time before July 5.

• The attempt to recover the re-entry capsule of Discoverer II, launched April 13, went awry because of a malfunction in the satellite's timer system. The capsule was ejected over Spitsbergen, Norway, when a "fail-safe" device went into action. Proper ground control of Discoverer II's timer was finally achieved in the 22nd pass, but the capsule had already been ejected.

• The Discoverer capsule weighs only 35 lb by itself, but its total weight, including retrorocket, parachutes, nose cone, and related recovery gear, is 195 lb. The capsule is fired backwards and downwards at a 60-deg angle from the horizontal to initiate the recovery operation. At an altitude 50,000 ft, a brightly colored parachute is deployed to slow the descent. Air Force C-119's, stationed at Hickam AFB, are positioned in the recovery area with special "trapeze" equipment to snatch the falling capsule from the air. Should they miss, the conical capsule floats in water with its radio beacon signaling for 10 to 18 hr.

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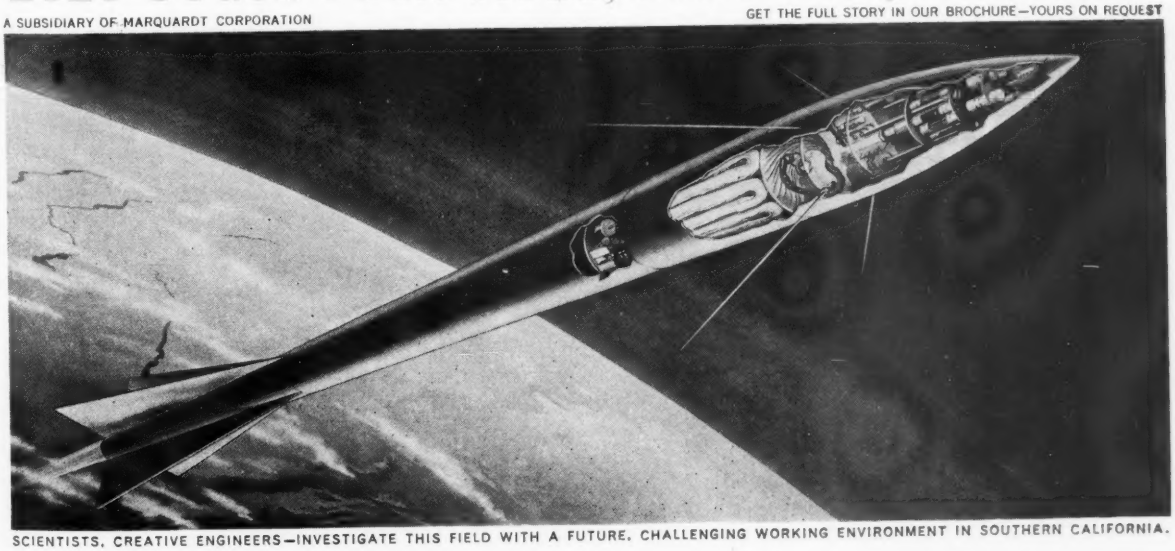

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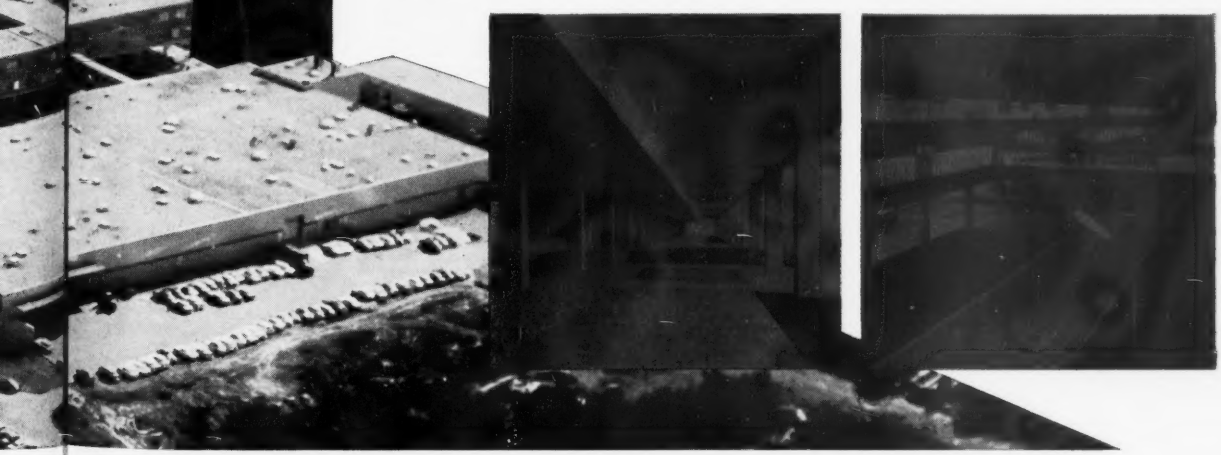

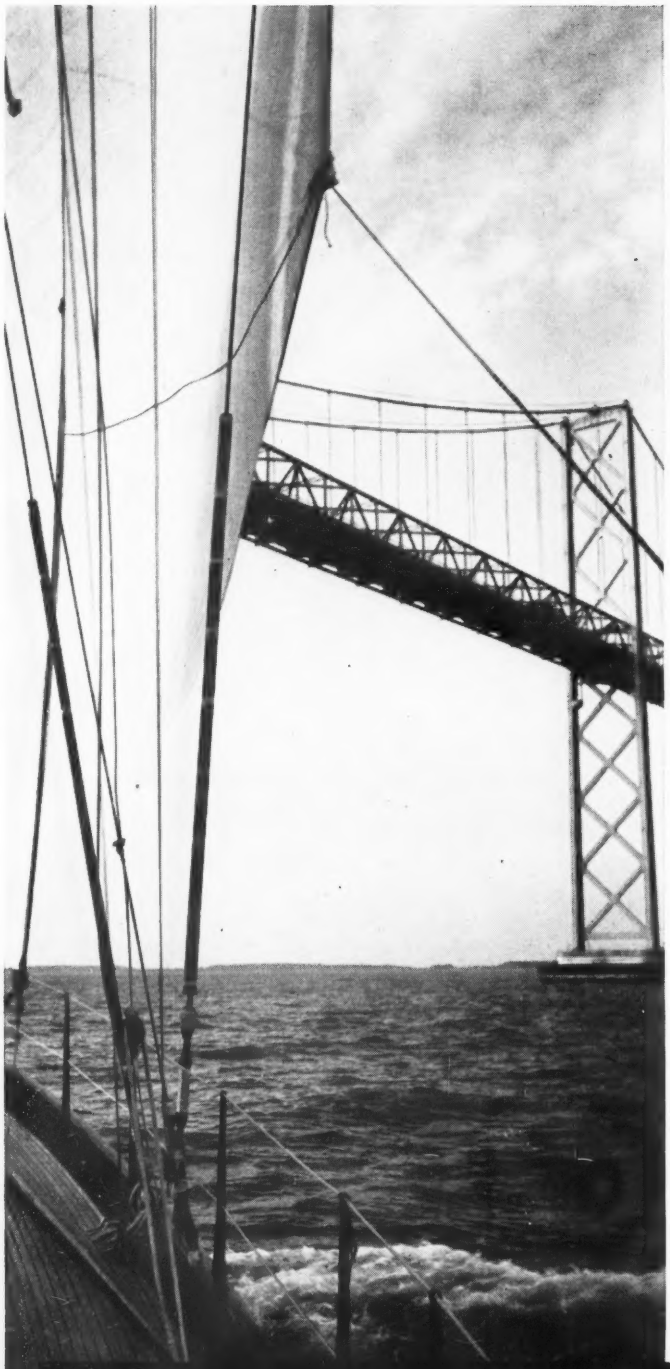

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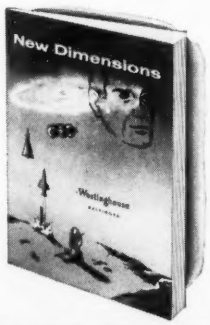

Westinghouse

BALTIMORE

• Failure of explosive bolts to operate satisfactorily gummed up the last Vanguard shot.

NASA

• Lunar Explorations, the third working group announced by NASA, will be headed by Robert Jastrow, head of NASA's Theoretical Div., and will include Harrison Brown and Frank Press of Cal-Tech, Maurice Ewing of Columbia, Bruno Rossi of MIT, Herbert Friedman of NRL, A. R. Hibbs of JPL, and James Heppner and Herman LaGow of NASA. This working group will study probes to obtain information on lunar environment, lunar satellites for determining the moon's mass and structure, and instrumented landing vehicles.

• Some $10 million in recent NASA contracts cover, among other projects, development by GE of a second-stage liquid propellant engine for Vega, a Bell Aircraft feasibility study for a fluorine-hydrogen engine, and Army Signal Corps work on IR radiation and heat-balance experiments for the Project Tiros meteorological satellite.

• NASA will continue the cooperation of this country and Canada in rocket and satellite studies of the upper atmosphere, having accepted the Canadian Defense Research Board's proposal to adapt Canadian instrumentation to NASA vehicles and to design and build additional ground facilities at Fort Churchill.

ARPA

• The proposed 1000-ton spacecraft propelled by a series of small nuclear explosions entered the feasibility study stage at General Dynamics' John Jay Hopkins Laboratory in San Diego. ARPA made $1 million available for the study in FY 1959.

ARGUS

• For the record, all three Argus blasts occurred at a nominal altitude of 297.6 miles, and yielded between 1 and 2 kilotons.

• Explorer IV, with three of its four radiation counters still working, traversed the artificial electron shell 164 times in places where its signal could be received and recorded. It noted the sudden drop of the first two Argus electron shells on Sept. 4, presumably because of perturbations in the earth's magnetic field induced by a great solar storm on that date. It monitored the shell from the third Argus shot

Shown 1/18 actual size

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for two weeks before its transmitter failed.

• A total of 19 Jason five-stage sounding rockets were fired from Virginia, Florida, and Puerto Rico to monitor the shots. Thirteen of the 19 successfully carried their payload of eight Geiger counters to an average altitude of 550 miles. Only the Jasons fired from Wallops Island, Va., actually penetrated the Argus shells, although the other rockets reported markedly increased counting rates as they approached the trapped shell of electrons.

• Measurable Argus effects included disturbances in the earth's magnetic field, interference with low frequency radio communications, production of a sporadic "E" layer in the ionosphere, and generation of a spectacular aurora.

FACILITIES

• Building partially hardened sites for Atlas, more fully-hardened sites for Titan, and test and prototype launching facilities for Minuteman, will eat up a good third of the Air Force's proposed $343 million construction funding for 1960. Other allotments in this AF program: $33 million for satellite launching, tracking, and data processing facilities; $33.5 million (in addition to last year's $189 million) for BMEWS equipment and first operational sites; $10 million for a hard-site NORAD center at Colorado Springs, Colo.; $76.3 million to put SAGE centers in hard sites; $10 million for Hound Dog and Quail assembly and checkout facilities in the U.S.; $27 million for five more Bomarc sites, bringing the number from 14 to 19; some $23.7 million for R&D facilities, such as a $5.7 expansion of Arnold Engineering and Development Center to allow study of airframes and engine components at orbital speeds, and a $7.3 million sonic-effects research laboratory at Wright-Patterson AFB.

• Aberdeen Proving Gound will soon have ready a Mach 10 wind tunnel, in addition to its present supersonic tunnel.

• Rocketdyne let a contract to Mid-Valley Utility Constructors of Houston, Tex., for a captive-testing stand at Edwards AFB that will take up to 1.5 million lb of thrust. Rocketdyne will operate the stand for NASA.

• Edwards AFB has completed a design study for a high-thrust fluorine test facility, and has begun shock-tube testing of the compatibility of fluorine with various materials and components.

SATELLITE TRACKING

• The new Army satellite detection station at White Sands has gone into 24-hr operation, with its receivers tied into the central U.S. tracking complex. It joins Army stations at Fort Sill, Okla., and Forest City, Ark.

SPACE LAW

• In the first meeting of the UN Committee on the Peaceful Uses of Outer Space, held in New York without participation of five of its 18 members—the U.S.S.R., Poland, Czechoslovakia, India, and the United Arab Republic—the U.S. proposed that liability for injury or damage caused by an artificial satellite returning to earth be considered first among the many legal problems associated with space flight.

MISSILES

• The Air Force selected Douglas to develop the air-launched ballistic missile through prototype production . . . Titan moved smoothly along in development with the fourth consecutive successful flight test. The missile's second stage, water-filled as in previous tests, was separated with two Grand Central Rocket solid auxiliary motors for the first time, one test ahead of schedule . . . The first Polaris launching submarine, the 5400-ton nuclear-powered George Washington, built by General Dynamics Electric Boat Div., slides down the ways at Groton, Conn., this month. It is scheduled for operational status in 1960 . . . The Jupiter missile, produced by Chrysler for the Army, has emerged successfully from tactical weapon tests.

• Striking a less optimistic note, the first operational Atlas ended as fiery fragments showered over the Cape Canaveral area when it became necessary to destroy it at an altitude of only 1000 ft. Also, another Atlas blew up during static testing at Edwards AFB.

• Navy BuOrd awarded Bendix Aviation $41 million in contracts for production of the Talos missile and engineering on prototype birds. The Navy expects to equip seven cruisers with Talos.

• RAF crews being trained with the aid of Douglas specialists fired their first Thor recently from Vandenberg AFB, and another proof-test Thor was fired on target from Cape Canaveral.

• The Army's Shillelagh, a light ground-to-ground missile designed by ARGMA for close support of troops, is under development by the Ordnance Tank Automotive Command in Detroit. Prime contractor for the missile system is Aeronutronic Systems. Aeronutronics has subcontracted development of the missile's fire control system to Raytheon, which will do the work at its Santa Barbara lab.

• Canadian and U.S. troops jointly will put the Hawk missile through a series of cold-weather trials, including actual firings, at Fort Churchill during the winter of 1959–60.

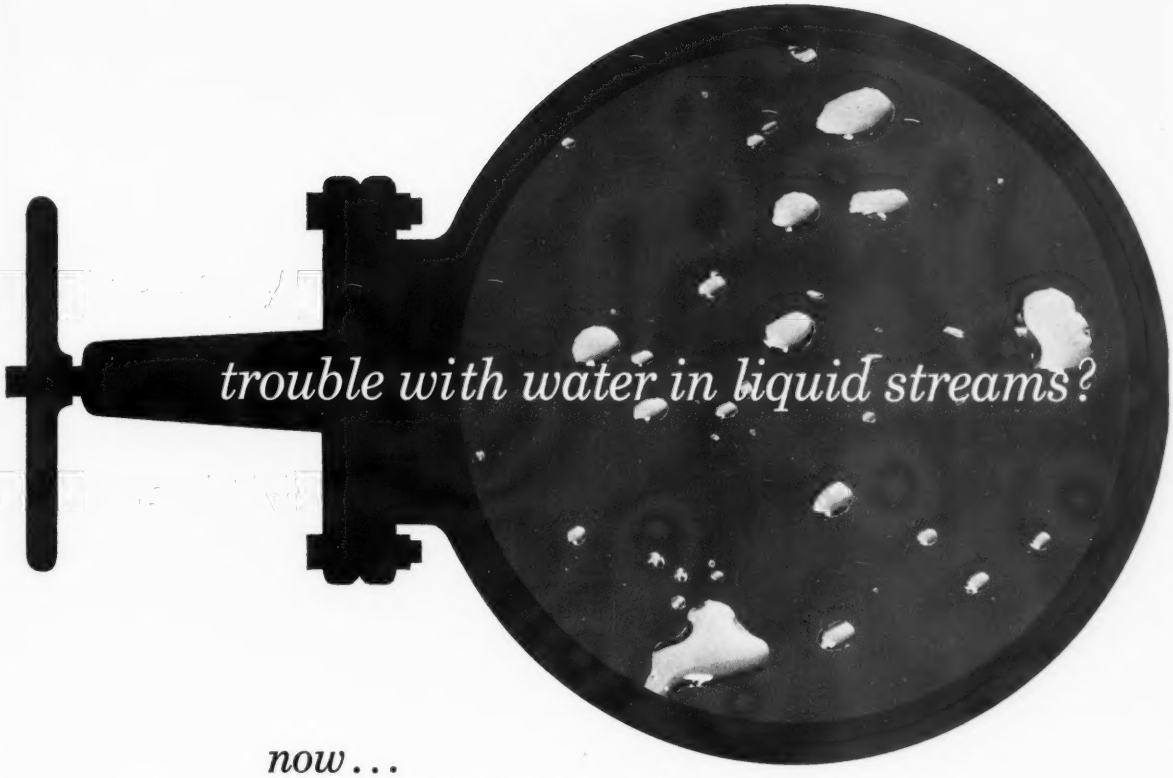
• Two Lacrosse surface-to-surface missile battalions, fully equipped with maintenance equipment, training devices, launchers, and missiles by Martin-Orlando, will be activated next month at Fort Sill, Okla. Lacrosse shows exceptional accuracy against point targets at ranges of conventional artillery.

R&D

• NSF director Alan T. Waterman, in testimony before the joint Congressional committee on economics, estimated U.S. research and development as a $10 billion industry—double what it was in 1953. The government finances more than half the R&D effort.

• President Eisenhower addressed leaders in science, government, and industry gathered in symposium under the joint auspices of NAS, AAAS, and the Sloan Foundation last month to discuss ways of improving the nation's basic research. Striking a keynote for the meeting, Warren Weaver of the Rockefeller Foundation commented, "What is of even greater importance (than the need for adequate funding) is that government, industry, and universities permit those engaged in basic research to carry on their work unhampered and unfettered by demands that they channel their efforts toward particular goals . . ." (Along these lines, see Wernher von Braun's tribute to Robert Goddard (on page 36) and Hermann Oberth's autobiographical reflections (page 38) in this issue.)

• Rocketdyne has static-fired a developmental version of its single-chamber 1.5-million-lb-thrust engine.



now...

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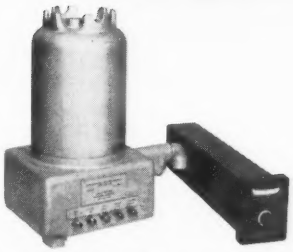

CEC's newest Process Moisture Monitor measures trace amounts of water in most organic liquids with sensitivity down to one part per million. Capable of continuous monitoring, the 26-312 makes possible replacement of laborious and time-consuming batch analytical methods. It creates a new means for quickly and positively identifying water in liquids such as: JP-4 and JP-5 jet fuel, naptha and xylene reformer feed stocks, F-11 and F-113 refrigerants, metal cleaning-system solvents, ethyl chloride, dielectric and hydraulic oils, aromatics, halogenated hydrocarbon liquids, and many polymers having moderate viscosities.

Operation of the 26-312 relies on a stripping column for removing all moisture from the liquid sample stream, and an electrolytic cell containing phosphorous pentoxide for absorbing and measuring the moisture. The cell is the same rugged, plug-in element used in all other CEC Moisture Monitors. The Analyzer Unit of the 26-312 is housed in a weather-tight, explosion-proof condulet suitable for installation in all Class I, Group D, Division 1 hazardous locations. The Control Unit is cable connected with the analyzer for remote location in the instrument room up to 500 feet away. To obtain further information on this instrument write for Bulletin CEC 1856-X1.

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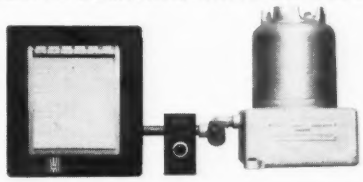

For Continuous Gas-Moisture Measurement . . . 26-310 Process Moisture Monitor. This Process Moisture Monitor repeats the liquid instrument's moisture measuring capabilities for gas and gaseous-mixture process streams. The analyzer is constructed with corrosion-resistant components, and also can be installed in Class I, Group D, Division 1 hazardous locations. Bulletin CEC 1845-X21.

• The 50,000-lb thrust RMI engine for the X-15 is reportedly set for flight readiness testing and is expected to be delivered to Edwards AFB in August and installed in a second X-15 recently shipped to Edwards by North American. First low-power flight tests of the engine are slated for December or January. Meanwhile, some minor problems have already been encountered in X-15 captive flight tests, with the APU system failing to operate properly in one such test.

• Edwards AFB has begun quick-fueling tests on Atlas, aimed at determining how quickly the missile can be readied for launching and whether fast-flow-rate principles are correct.

• Edwards also has a valve and regulator evaluation program underway. New equipment now being installed will permit testing of valves and regulators at temperature and pressure ranges hitherto not achievable.

• Edwards recently completed a series of large-scale fluorine spill tests in a study of decontamination and neutralization procedures, and the effects and dangers involved in spilling large quantities of fluorine.

• Astrodyne successfully static-fired its "aluminized" ammonium perchlorate cast solid propellant in a motor casing 16 ft long and 27 in. in diam. The motor gave 45,000 lb of thrust.

• Ion engines for satellite attitude control and orbital adjustment are well into the experimental stages at NASA, GE Aviation Gas Turbine Div., and Rocketdyne, among others. Aerojet-General is experimenting with a "cold" system employing colloidal droplets of oil, rather than metallic ions.

• Hydrocket and Aeropak are two other novel Aerojet projects. Hydrocket, a jet engine to which water is fed as a working fluid by a very high speed impeller, can increase the speed of present hydroplanes at least 75 per cent, Aerojet engineers believe. Aeropak, a hydrogen peroxide engine with a gimbaled thrust chamber and fuel metering for control, is being tested as a one-man flying belt.

• NASA is building two small research loops to study cesium and rubidium as heat transfer mediums for nuclear propulsion systems.

• Declaring that widespread lack of understanding of instrument calibration threatens interchangability of rocket and missile components, Allen V. Austin, director of the National Bureau of Standards, speaking at the annual meeting of the Scientific Apparatus Makers Assn., called for greater appreciation of the need for well-calibrated instruments, particularly those used to control production, and listed these R&D areas as having critical measurement problems: High temperature, high pressure, large force, and telemetry systems, and the characterization of pure substances in solid-state technology.

MATERIALS

• Westinghouse scientists have invented a process for growing ribbons of germanium of a thickness and smoothness directly usable in semiconductor devices. ARDC awarded Westinghouse a $2 million contract for further development of the process.

• Some 200 scientists from across the country met at Lockheed Missiles and Space Div. during May to discuss surface effects in spacecraft materials.

• Several groups, among them Thompson Ramo Wooldridge, Battelle Memorial Institute, and GE, are studying columbium, which has high melting point and high resistance to oxidation, for possible use in nose cones, leading edges of hypersonic vehicles, etc.

• Fansteel Metallurgical has just introduced a series of columbium-base alloys, one with a melting point of 4550 F. Two of the series are commercially available.

• Dow Chemical has developed an alloy of balance magnesium, 0.6 per cent zirconium, and 3.2 per cent of the rare earth, didymium, for missile applications. Sand-cast, the alloy shows good tensile strength up to 600 F and excellent creep resistance at this temperature for up to 10 hr. It can be forged and welded.

• American Potash and Chemical believes its newly synthesized phosphinoborines may make certain plastics stable at temperatures up to 750 F. Most present plastics do not remain stable above about 300 F.

• Armco's precipitation-hardened stainless steel, Ph 15-7 Mo, has been selected for the main sheet construction of the B-70 and F-180 jet aircraft, which will be capable of Mach 3. Armco expects precipitation-hardened steels of even better properties for hypersonic vehicles to come from its current development programs.

• Two rare metals, scandium and neodymium, will soon undergo extensive testing for possible use in the missiles and space vehicles. Union Carbide received $60,000 in AF contracts to investigate the properties of scandium, which has a density about equal to aluminum but a considerably higher melting point. One pound of scandium, costing about $20,000, will be produced for testing. Nuclear Corp. is already producing neodymium at an approximate sale price of 70 cents per gram.

• The corrosion resistance of titanium has been extended well into the area of a reducing environment by the addition of as little as 0.1 per cent by weight of palladium, according to Union Carbide. The addition of up to 0.2 per cent of palladium does not change the physical properties of titanium, and does not increase its cost appreciably. Union Carbide will license production of the alloy to mill producers of titanium.

• Chromalloy's Propellex Div. announced development of a new composite solid propellant with low temperature coefficient. Now being made on pilot-plant scale, the propellant appears most suitable for small booster and spin rockets, auxiliary power units, pilot-ejection motors, and the like. Propellex is also working successfully with explosive forming of metal for rocket booster cases.

INDUSTRY

• The Gabriel Co. of Cleveland, Ohio, will build a solid propellant plant to be known as Rocket Power, Inc., at Mesa, Ariz., near its wholly owned subsidiary Talco Engineering. Charles E. Bartley, founder and former president of Grand Central Rocket, will head Rocket Power Inc., and Frank A. Marion, former assistant vice-president at Grand Central, will be executive v-p.

• Beryllium machining only will be done at the new Alsca Beryllium Machining Corp. plant at Valley Stream, N.Y. Specifically designed for safe handling of beryllium, the plant will at first turn out custom-machined electromechanical components for missile and space research programs.

• Stanford Research Institute will expand its research program in rocket propellants and propulsion devices, partially because of its

Philco Ground-Space Communications System commands and tracks **DISCOVERER** satellite

DISCOVERER . . . the United States' newest earth satellite . . . is opening new vistas on the frontier of outer space. And Philco is proud to play an important role in this renowned achievement as a part of the Discoverer Team . . . in conjunction with the Lockheed Aircraft Corporation and the Air Force at the direction of the Advanced Research Projects Agency of the Department of Defense.

As the subcontractor for Discoverer's entire communications system, Philco designed and developed the vast complexity of ground-space communications, tracking, commanding and data gathering and processing systems.

The Philco-designed and equipped system observes and commands Discoverer through a series of five tracking and data collection stations in Alaska, California, Hawaii and a specially equipped ship at sea. Philco continues its participation in the Discoverer Program by assisting in the actual operation and maintenance of the communications and data handling network.

Philco's part in the Discoverer Program is typical of the many and diverse advanced research and development activities being conducted in our laboratories on the East and West Coasts where outstanding career opportunities abound for Engineers, Mathematicians, and Physicists.

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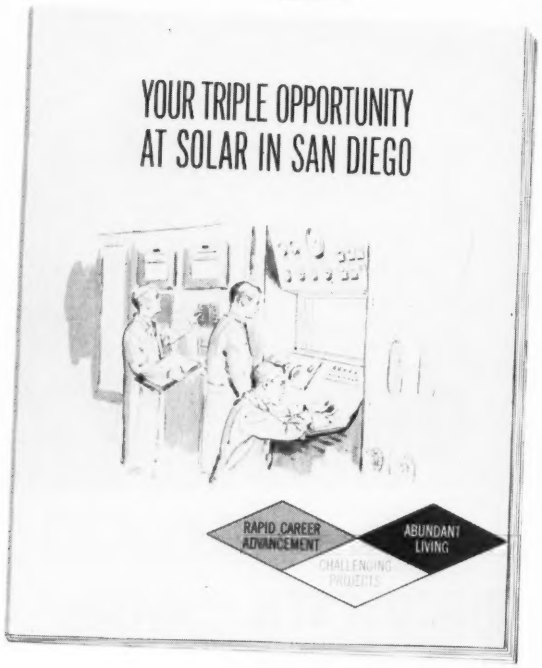

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SOLAR AIRCRAFT COMPANY — SAN DIEGO, DES MOINES

work under contract to United Research, a United Aircraft subsidiary.

• ABL will be using a 25-million-volt betatron, made by Allis-Chalmers, to detect flaws in solid propellant grains for Polaris.

• Grand Central Rocket will add several hundred thousand dollars in static-firing, production, and administrative facilities to its research center and motor-testing grounds in Calif.

EDUCATION

• The Univ. of California Extension Div. at Los Angeles will be giving eight two-week sessions in astronautics, rocketry, and associated studies this summer, featuring such short courses as Nuclear Rocket Propulsion Systems (July 27 to Aug. 7), led by Robert W. Bussard and Richard De Lauer, and Astrodynamics and Rocket Navigation (June 22 to July 3) led by Robert M. L. Baker.

UNITED KINGDOM

• The British Minister of Supply described as "a little premature" a suggestion that the U.S. launch a satellite from Woomera. . . At Australia's Port Hedland, some 1250 miles down range of the main Woomera test area, will be built a "prefab" town, known as Talgarne, with adjoining airstrip and technical facilities, which will serve as an observation station for long range missiles launched over Woomera, and possibly as one of the Mercury tracking bases. . . New range equipment is being poured into Woomera, evidently to prepare it as a satellite-launching area as well as to increase its facility to track long range missiles.

• Britain is continuing development of the Bristol-Ferranti Bloodhound, a missile roughly equivalent to Bomarc, for area defense against aircraft and long range missiles, and is pushing Blue Streak as a storable liquid propellant IRBM for hard sites. . . Blue Streak is expected to be tested over the full length of Woomera early in 1960. . . The Malkara anti-tank missile has been successfully field-tested in Scotland, and is expected to serve Britain as an interim anti-tank weapon until a more sophisticated one is developed. . . Australia has launched at least six of its Long Tom upper atmosphere research and range-test rockets since last October, but does not expect to replace the IGY Skylark with it as it

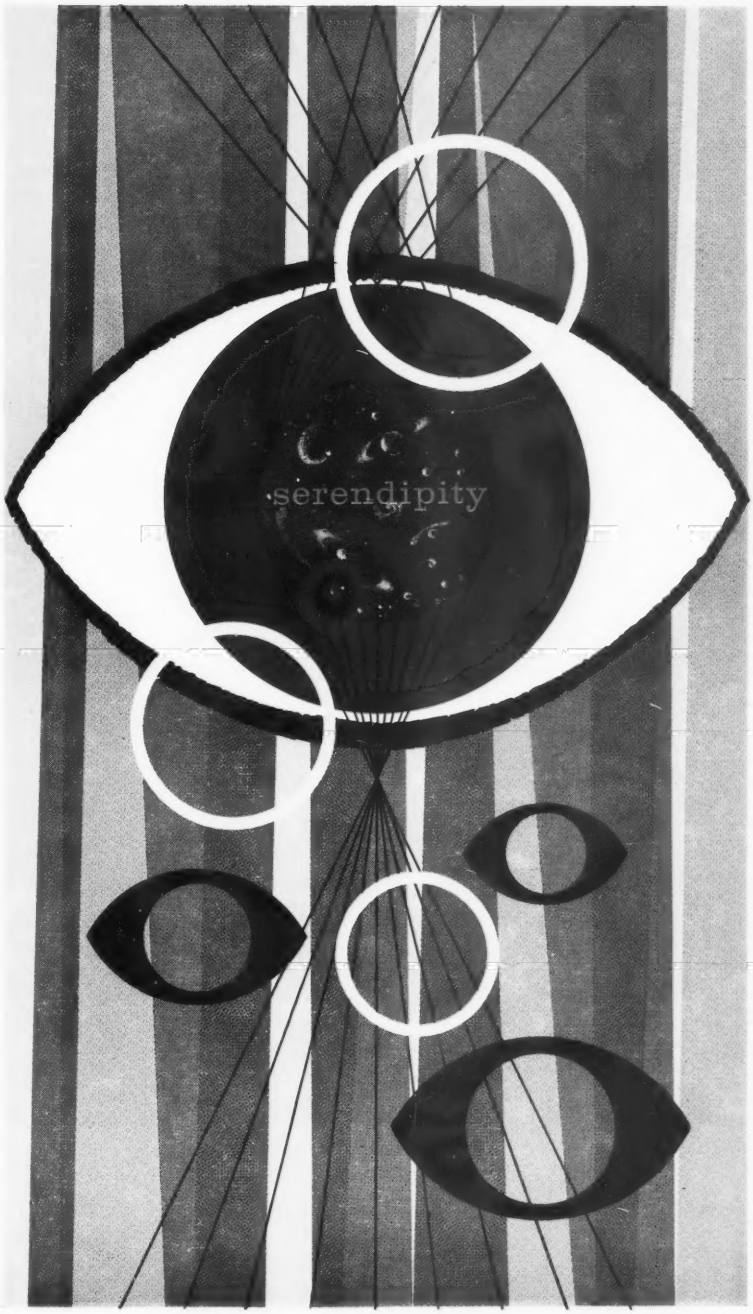
has less payload. Long Tom incorporates four standard British rocket motors. . . The Australian government is looking for an inexpensive and highly mobile ground-to-air missile system to provide the basis of the country's defense with ground-fired weapons.

• Work has resumed on the Royal Greenwich Observatory's prospective 98-in. reflecting telescope, the Isaac Newton, which is based on a test blank cast in 1936 for the 200-in. Palomar telescope.

EUROPE

• The unclassified AGARD meeting on the chemistry of propellants being held at NATO Headquarters in Paris this month will conclude with a round-table discussion featuring such notables as T. von Kàrmàn, A. D. Baxter, J. W. Bond, A. Ferri, G. B. Kistiakowsky, H. W. Ritchey, and M. Roy. . . Last month, AGARD scientists assisted the Univ. of Rome faculty in presenting a two-week seminar series for students and junior researchers on trends in astronautics, upper atmosphere physics, re-entry and heat transfer, communications, etc. . . May also saw Greek scientists meeting in Athens under AGARD sponsorship to hear about latest advances in medical and human engineering aspects of flight, including escape and survival in ballistic vehicles. General Don Flickinger gave the keynote address at this meeting.

• The Italian Senate had not yet approved establishment of Jupiter squadrons in their country as ASTRONAUTICS went to press. . . Oerlikon has added its Mosquito, a version of the Swiss Kobra I, to contestants for U.S. Army and Marine Corps contracts for an anti-tank missile, joining the Vickers Vigilant and the German Cobra and the front-running French SS-10. Hicks Development Co. would manufacture the Mosquito in the former Oerlikon plant in North Carolina. . . Sweden and Australia both expect to receive Sidewinders to arm their British interceptor aircraft. . . Ratification of a binational constitution for the well-known Saint-Louis Research Laboratory directed by H. Schardin constitutes a milestone in the German-French missile alliance. . . Sweden is reported testing an all-weather air-to-ground guided missile. . . The 2nd International Congress on Rockets and Satellites convenes in Paris this month.



look for the professional challenge . . . *available only to those who possess the creative initiative to explore, in thought, beyond what is known about space travel, and return with the serendipity that only the few would recognize. If you are one of those exceptional individuals who is seeking a challenge such as this, communicate with N. M. Pagan, Director of Technical and Scientific Staffing, Martin-Denver, P. O. Box 179, (B-3), Denver 1, Colorado.*

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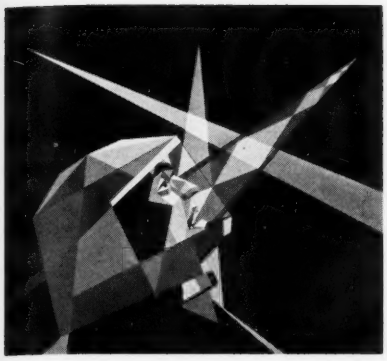


COVER: *"Man in Space," a striking impression of the first spaceman by well-known artist (and good ARS member) Mel Hunter.*

Astronautics

JUNE 1959

Community of Interest

The time has come to devote more of our energies to informing and guiding the community at large, and particularly its young people, in rocketry and astronautics. It is incumbent on ARS to pioneer in space education even as it has in fostering research and development in rocketry and astronautics.

The ARS report on amateur rocketry (see page 34) prepared by the Southern California Section under the able leadership of Jack Schafer, is a worthy pioneer effort in this direction.

In the report, ARS takes a definite stand against amateur experiments with rocket propellants or devices which use them. This action recognizes a moral obligation for the safety of our youth.

While taking this stand, the Society also assumes responsibility for advancing the education of students in the *science* of rocketry and astronautics safely, intelligently, and profitably with every means at its disposal.

The report suggests three areas where our action is needed—tutoring enthusiastic and talented youngsters; speaking on larger issues to parents and teachers, the adults most directly influencing young people; and inspiring and guiding community programs aimed at a better understanding of astronautics and its growing impact on our daily lives.

The Society has taken some action along these lines through both the sections and the national office.

Several ARS sections have undertaken successful seminars for high school and grade school teachers. This kind of program will introduce space science into the public and private school curriculums much more effectively than programs which tend to compete with the school systems, and at the same time it will foster community good will.

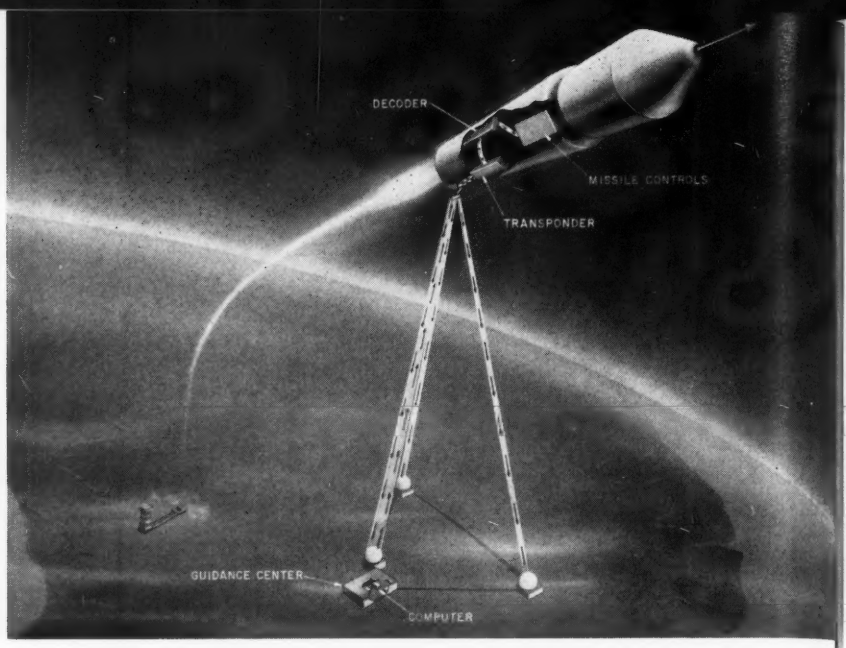
The ARS national office has published two careers-in-astronautics booklets and will soon issue a 16-page summary of the amateur rocketry report for nationwide distribution to students.

Also, the Society plans a student and teacher tool—a book of carefully designed experiments, safe and practical to carry out, which will inform the student in principles of rocketry and astronautics. These experiments should come from our unique experience as engineers and scientists, and should be sent to John Newbauer at our New York office for editing and publication this fall.

Our programs, in being and planned, must exploit our real wealth, ourselves—our knowledge, experience, and skills. The ARS report on amateur rocketry and these initial programs suggest how our talents can be applied now, when they are much needed.

John P. Stapp
PRESIDENT, AMERICAN ROCKET SOCIETY

RADIO GUIDANCE SYSTEM



Radio guidance of vehicles into space

Radar ranging and radio command offer the high accuracy and reliability necessary for putting manned vehicles into precise orbits

By Earle B. Mullen

GE DEFENSE SYSTEMS DEPT., SYRACUSE, N.Y.

Earle B. Mullen is a staff engineer of the Defense Systems Dept. Electronics Div. He received an M.A. in physics from the Univ. of Toronto in 1948. His background includes prospecting in Canada and Arizona and teaching at the Univ. of Scranton. Since joining GE in 1952, he has worked on microwave ferrites, atmospheric and ionospheric effects in radio propagation, and systems analysis of guidance systems for satellites and other space vehicles.

GUIDANCE accuracy and reliability for manned space vehicles are going to be considerably higher than what sufficed for unmanned satellites and space probes. The nervous occupant strapped into a seat in the modified nose cone of an ICBM on the launch pad would undoubtedly like to have assurance that continuous ground control can be maintained during the initial powered phase of the flight and that the launching officer has precise knowledge of orbit-insertion conditions at the instant freeflight conditions begin.

A radio command-guidance system offers just such assurance through its ability to track and guide in real time. And by proper design, it can be made to have the highest standards of accuracy and reliability available today, thereby increasing the probability for successfully putting space vehicles into precise orbits.

Conceptually, the operation of a radio guidance system is very simple. Referring to the illustration above, the position and velocity of the boost vehicle is measured with a precision radar system, and this information is compared with a predetermined trajectory stored in the computer. The computer calculates the increments of the velocity component required to keep the vehicle on course. These increments are then encoded and transmitted to the vehicle via a data link. Actually there may be a great deal of flexibility allowed in formulating the commands for the vehicle since, as a rule, the

requirement to keep it along a definite "wire" in space is overly stringent.

A sophisticated computer can continuously be predicting the impact point for a missile, or the insertion parameters in space for a satellite or space probe, and supply the thrust-cutoff command instantly when the right combination of position and velocity vectors is attained to reach the objective. By thus transferring a large part of the navigational burden to the ground computer, it is sufficient to keep the vehicle flying in a nominal "tube" rather than along a definite "wire."

Let us now examine a little more closely what is involved in obtaining very precise position and velocity measurements. First of all, it is evident that passive tracking is not adequate for following or guiding the vehicle out to long distances. The radar range equation shows that for a distant missile the returned power, which varies as $(\text{range})^{-4}$, is so small a fraction of the transmitted power that impossibly high demands are put on the sensitivity of the receiver. This difficulty is mitigated by using a transponder on the vehicle which receives the signal from the ground and retransmits a very strong signal back. In this way the power dependence on range is improved to vary as $(\text{range})^{-2}$. By using large antennas on the ground and sophisticated modulation and detection techniques, very long ranges can be achieved for remarkably small power output from the transponder.

Range can be obtained most simply by timing the round trip of a pulse, or other suitable form of modulation, from the ground station to the space vehicle and back. There are other, less direct methods involving triangulation to a number of stations which may also be used. A small correction will be necessary for the turn-around time in the transponder, but this presumably can be measured beforehand.

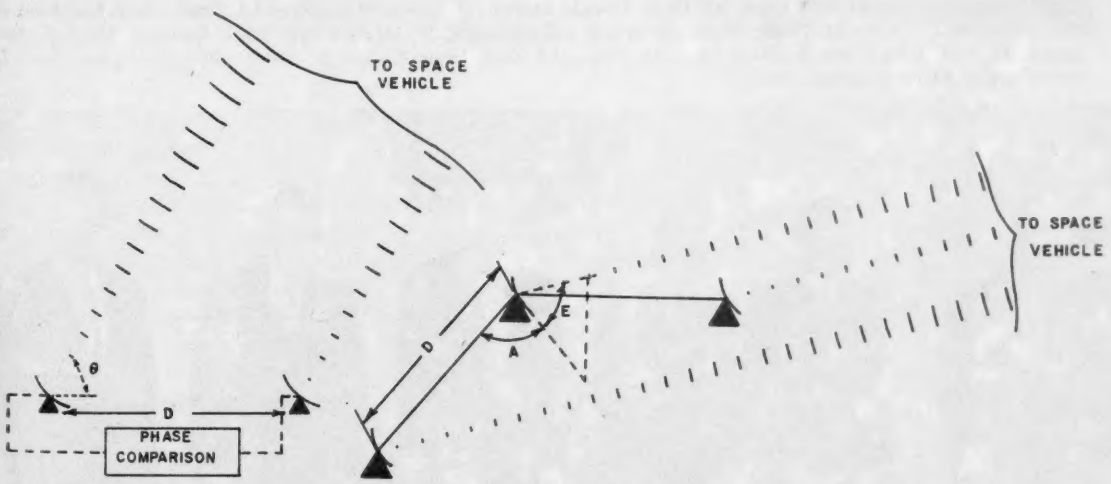
Assumed Errors for Radar

Radar observable	Standard deviation, σ
Range (R)	250 ft
Range rate ($\dot{R}$)	10 fps
Elevation angle(E)	1 millirad
Elevation angle rate($\dot{E}$)	10 millirad/sec

Vehicle Angular Position

The angular position of the vehicle can be calculated in a number of ways. The simplest way immediately presenting itself is utilizing three radars in a noncollinear configuration to obtain three values of range to the target. Simple triangulation then gives the position vector with respect to a reference point on the ground. However, it is easy to show that for highly accurate angle information the distances between the triangulation stations must be very large.

Accurate angle data are more readily obtained for a reasonable baseline (CONTINUED ON PAGE 66)



Radio interferometer (left) and double radio interferometer system (right).

The Mercury astronauts

Their comments reveal the motivating factors behind man's desire to go into space-exploring the unknown, faith, duty, country

WHAT makes a man want to be an astronaut?

The replies of the seven men selected by NASA for the Project Mercury tests to the question of why they had volunteered for space experiments provide a fascinating insight into the motivation behind their volunteering for the tests.

Capt. Virgil I. Grissom (USAF), 33, of Mitchell, Ind., said simply: "My career has been serving my country, and here is another opportunity where they need my talents. I'm just grateful for the opportunity. . ."

Lt. Col. John H. Glenn Jr. (USMC), 37, New Concord, Ohio, the lone marine selected, had another explanation. "My feelings are. . . it's like the Wright brothers, who stood at Kitty Hawk about 50 years ago with Orville and Wilbur pitching a coin to see who (would) shove the other off the hill. . ."

"I feel this is the future not only of my country but the world," was the comment of Capt. Donald K. Slayton (USAF), 35, Sparta, Wis. "We've gone about as far as we can on this globe, and we have to start looking around a bit."

Lt. Cmdr. Alan B. Shephard Jr. (USN), 35, East Derry, N. H., said we were obviously on the threshold of space travel and he wanted to be in on it. Another Navy man, Lt. Malcolm S. Carpenter, 33, of Boulder, Colo., echoed Capt. Grissom, noting that this represented a chance "to serve the country in a noble cause." A third Navy flier, Lt. Cmdr. Walter M. Schirra Jr., 36, of Hackensack, N. J., said he was merely carrying on the tradition of his father, a very early airplane pilot.

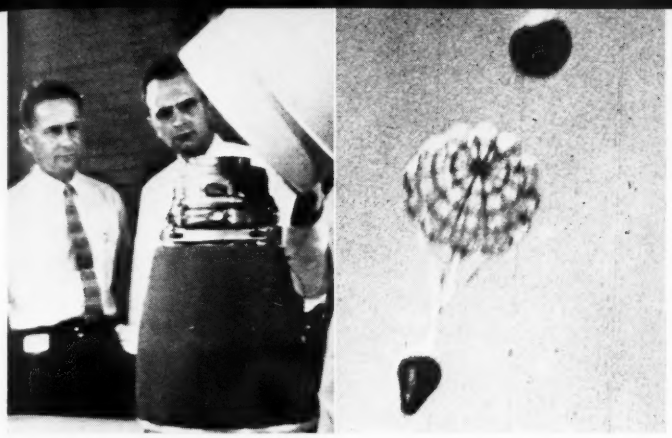
Capt. Leroy G. Cooper Jr. (USAF), 32, of Carbondale, Colo., stated: "I am a career officer and career pilot, and this is something new and very interesting."

Comments Were Exciting

As James Reston commented in a *New York Times* article, it was exciting to hear them talk of the heavens the way the old explorers talked of the unknown seas. "They wanted to see what was 'on the other side'," he noted, and their remarks about duty, faith, and country came out of deep-felt idealism and courage.

The seven Mercury astronauts are now undergoing orbital flight training with the Space Task Group of the NASA Space Flight Activity at Langley Field, Va. Each will (CONTINUED ON PAGE 42)

The Mercury astronauts: From left, AF Capt. Donald Slayton of Sparta, Wis.; Navy Lt. Cmdr. Alan Shephard Jr., East Derry, N. H.; Navy Lt. Cmdr. Walter Schirra Jr., Hackensack, N. J.; AF Capt. Virgil Grissom, Mitchell, Ind.; Marine Lt. Col. John Glenn Jr., New Concord, Ohio; AF Capt. Leroy Cooper Jr., Carbondale, Colo.; and Navy Lt. Malcolm Carpenter, Boulder, Colo.



Left, Jupiter-C recovery package during assembly, with protective shell not yet in place; right, package in action in early test of system, showing drag parachute deployed and flotation balloon ejected and trailing.

Techniques for space vehicle recovery

Research on parachute systems has helped pave the way for design of manned satellites and space-vehicle emergency escape capsules

By Harold V. Hawkins

COOK RESEARCH LABORATORIES DIV. OF COOK ELECTRIC CO.

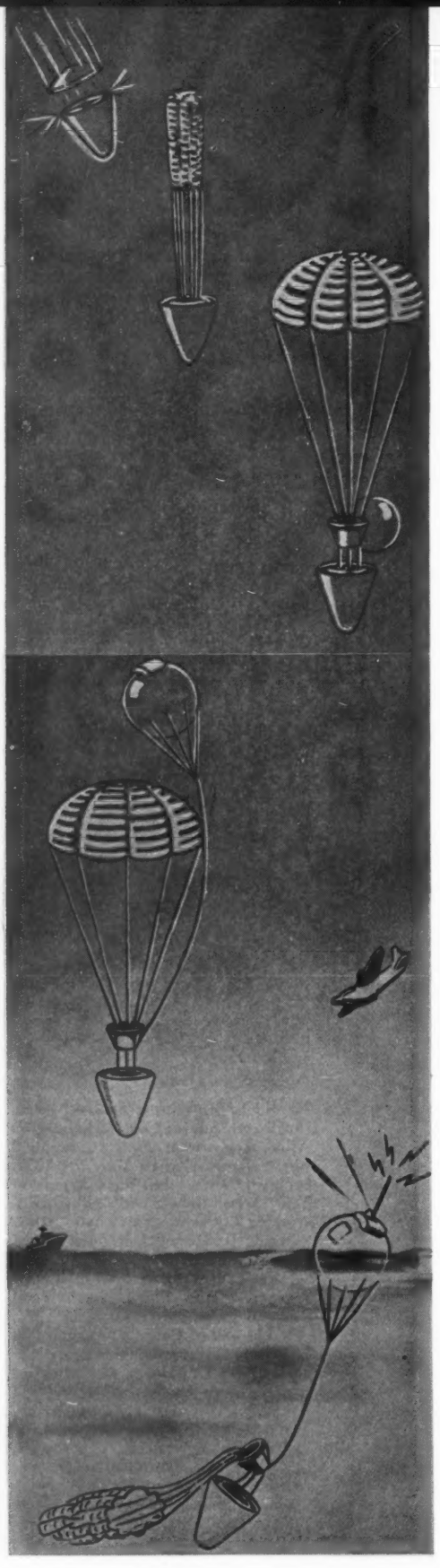
MORTON GROVE, ILL.

THE RECOVERY of space vehicles is rapidly becoming an important phase of our all-out missile effort and will be crucial to Mercury and similar projects. When heat-sink warheads were the prime consideration of our spaceminded military weapons developers, only a very secondary role was given to recovery of nose cone packages. This came out of a basic decision that the heat-sink type of protection for bodies re-entering the atmosphere was amenable to analytic treatment, with telemetered flight information providing any additional evidence deemed necessary for the hurried development programs then in progress.

Moreover, these programs did not allow for any delays that might be caused by secondary programs of questionable benefit to immediate needs. Only basic research in high Mach-number drag devices sponsored by Wright Air Development Center kept a moderate program of recovery system development active. In addition, the Army Ballistic Missile Agency recognized the need for re-entry recovery, and contracted with Cook Research Laboratories for recovery of the Jupiter-C and Jupiter nose cones.

The impact of the Sputniks on our scientific endeavor gradually brought other space objectives into the forefront. Manned satellites and many geophysical investigations have made mandatory the development of a variety of recovery systems. Moreover, more advanced types of re-entry thermal protection than the heat-sink type are pointing up the need for a look at that portion of the system which survives the terrific thermal conditions encountered during re-entry. Agencies which previously spurned this area are now asking for accelerated programs, while newly formed space agencies are carrying out intensive programs to educate their personnel in recovery techniques.

Harold V. Hawkins is assistant director of research for Cook Laboratories. After receiving a Ph.D. in applied physics from Cornell Univ. in 1937, he taught there until the outbreak of WW II, and then joined Bell Aircraft, working first as a stress analyst, then vibration engineer, and finally chief of electronic engineering. From 1947 to 1951 he was professor of civil engineering at the Illinois Institute of Technology, and from 1951 to 1954, when he joined Cook, he was director of engineering for Globe Corp.'s Aircraft Div. Dr. Hawkins' experience includes both technical direction and engineering in design and test programs on missile and aircraft parachute recovery systems; pilot escape systems; radio-controlled target aircraft; flight test systems for research aircraft and helicopters; man-carrying radio-controlled aircraft; and associated analytical work.



Recovery of space vehicles generally may be divided into four categories, as follows:

1. Systems calling for the recovery of primary bodies having high terminal velocity close to the earth's surface.
2. Systems involving the recovery of secondary bodies, such as data capsules, that are ejected from primary re-entry bodies during or after re-entry.
3. Systems which provide for the primary recovery of manned capsules.
4. Systems which provide for a secondary recovery capability for manned flight vehicles.

All four categories are governed by the basic ballistic and aerodynamic laws which determine space travel. However, the character of the cargo and the specific missions involved generally cause systems 1 and 2 to require recovery under conditions of extreme velocity and deceleration at low altitude. On the other hand, only very moderate deceleration can be tolerated for systems 3 and 4, so that significantly lower terminal velocities are possible, which in turn makes altitude a much less critical factor.

A recovery system will generally include all or part of the following subsystems:

1. Means for initiating departure from a satellite orbit or from a parent re-entry vehicle.
2. Sensors for detecting the beginning of re-entry into the atmosphere and initiating the terminal recovery phase.
3. Means to decelerate before impact.
4. Impact absorbing capacity.
5. Flotation gear, if water recovery is contemplated.
6. Location devices.

Since the performance of each subsystem is strongly influenced by the general factors that control the re-entry trajectory, pertinent characteristics will be discussed briefly here.

The entire ballistic re-entry process is governed by the velocity the body has when it arrives at an altitude of approximately 300,000 ft, the angle (θ) that its flight path makes at that time with the horizontal, and its ballistic coefficient, $c_B = C_D A/m$, where C_D is the effective drag coefficient, A the frontal area, and m the mass of the re-entering body. Flight above that altitude is essentially frictionless. For example, the dynamic pressure of the atmos-

Jupiter-C nose cone recovery. Top to bottom, rear cover of hot nose cone ejects; ribbon parachute deploys at about 1-mile altitude; inner compartment releases and balloon inflates; balloon trails above descending cone, and then assembly enters water. There, water actuates antenna-erection mechanism and turns on transmitter, dye releases to mark landing area, and shark repellent protects balloon.

phere is only 8 lb per sq ft for a speed of Mach 10 at 250,000 ft altitude.

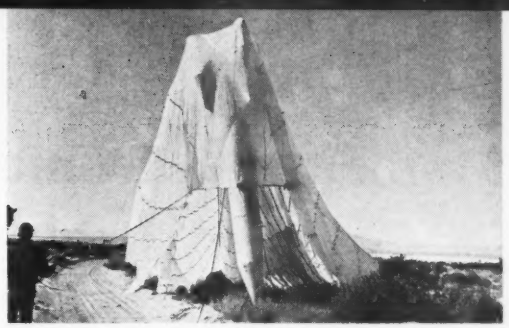
Thus, a re-entering body above this altitude accelerates along its path under the influence of gravity as it follows the characteristic elliptical path of a satellitic body. Of course, even a small amount of retardation would prevent unlimited time of flight at that altitude, but the decelerative effect of the upper atmosphere is too small to be of significance in a useful recovery situation.

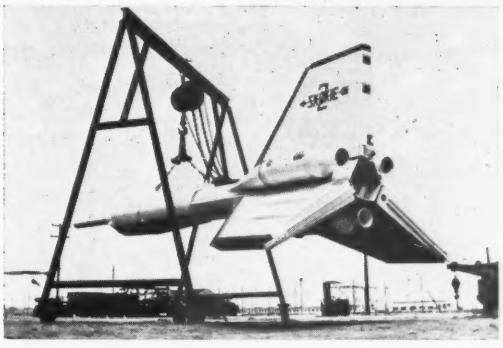
This high efficiency of flight in the upper atmosphere also leads to the difficulty of terminating a satellite's motion once it is established in a stable orbit. There being nothing tangible to grab hold of at this altitude, its path must be altered forcefully. By application of a small increment of thrust counter to its motion, a satellite can be made to enter a new elliptical path toward a new perigee closer to the earth. When the body arrives at an altitude of 300,000 ft, it is said to be re-entering, and its velocity and attitude to the horizontal then become the determining factors in the subsequent re-entry phase.

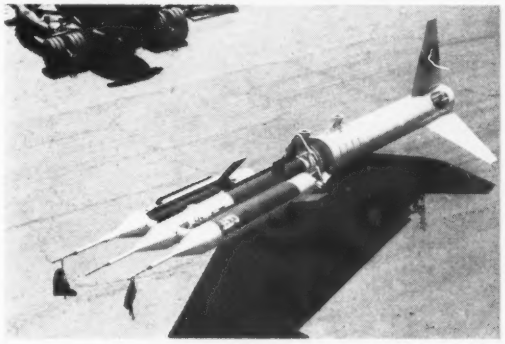
Fuel Must Be Carried

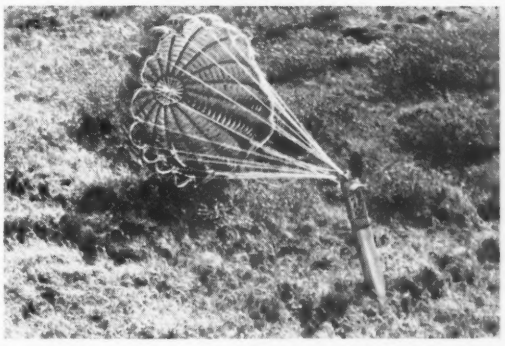
Thus, fuel must be carried aloft to start the return trip back to earth. For example, 65 lb of fuel (with a specific impulse of 250 sec) is the minimum required to cause a satellite weighing 1250 lb to leave an orbit of 325 miles altitude and descend to a stable 60-mile circular orbit, after 25 complete orbits. Another 2750 ground miles would be traveled before it finally impacted on the earth. The total distance traveled during the re-entry phase can be reduced by application of a larger impulse at the start or by a second impulse applied at any subsequent apogee.

Descent from the re-entry altitude of 300,000 ft can be controlled (1) by use of additional thrust increments, (2) by deploy- (CONTINUED ON PAGE 94)









Data from research parachute-recovery systems are contributing to design of manned satellites and space-vehicle pilot escape capsules. Parachute systems designed and developed by Cook Research includes (top to bottom) Skokie I, a subsonic 2600-lb vehicle recovered with 88-ft diam skirt-type parachute and impact spike; Skokie II, supersonic parachute test vehicle, which drops test parachute and first-stage recovery chute from doors on two lower fins and ejects final-stage recovery chute from large forward compartment; three Cree test vehicles mounted for balloon, ground, or aircraft launching with a Nike booster, from which each Cree will separate and eject chute; Nike-Cajun nose section at impact after Mach 5 descent from 72-mile altitude; and section of Nike-Cajun with dive brakes, radio beacon, and parachute pack.

Medical electronics— black bag in space

Specially designed instruments monitoring the first space men will help insure their safety and provide design data for future spacecraft

By Irwin I. Steinberg

GULTON INDUSTRIES INC., METUCHEN, N.J.

THE NAMING of the Project Mercury astronauts has helped to focus attention on medical problems of the man-in-space program. Although the expected environmental conditions of space have been studied in the laboratory, with the space pilot in mind, the actual environment of space and what effects it will have on man are not known, and will probably not be known until a manned satellite orbits the earth.

For both scientific reasons and for the safety of the space pilot, then, it appears that constant medical monitoring of the first man in space will be a major design goal, as important, for instance, as the capsule heat-protection and atmospheric-control systems. That is, we can expect that information on the physical condition of the first astronaut will shape further design of space vehicles and their flight paths; and we can hope that enough will be known of his condition at any time to return him safely to earth should a physical or mental hazard endanger his life.

The space pilot's physiological and psychological responses will doubtless be followed with a complex of medical-electronic instruments and data from them telemetered to earth. What the instruments will be like depends on what measurements need to be made, and can be made, on the pilot without encumbering him or restricting his limited field of action. The measurements must be of a kind and number that will be accurate, reliable, and readily diagnosable.

In recent years, Gulton Industries has studied the design and function of instruments appropriate to the monitoring of a space pilot. Our work on medical-electronic instruments has revolved about 10 basic conditions: Skin temperature; breathing flow, rate, and volume; the electrocardiograph (EKG); heart rate and sounds; systolic blood pressure; galvanic skin response (GSR); and the electroencephalograph (EEG).

Brief sketches of the instruments developed for these measurements will indicate the kind of medical electronics we believe are of interest for monitoring man in space.

A relatively simple instrument measures skin temperature. It consists of a bead thermistor—a temperature-sensitive semiconductor—embedded in an epoxy resin and stainless-steel abrasive base. It can be taped to any part of the body, the abrasive base preventing movement of the probe after taping, and with the aid of an AC bridge circuit will readily respond to changes in skin temperature. The photo at bottom right of the page opposite shows a clinical version of the bead thermistor for hospital use.

Irwin I. Steinberg is general manager of Gulton's Vibro-Ceramics Div. He graduated from the U.S. Military Academy in 1950 after previous studies at Purdue Univ. and NYU and WW II service in the Army Air Corps. He joined Gulton soon after leaving the service in 1954, and for the past two years has been closely associated with the company's medical electronics program.

A new and fairly sophisticated device uses strain-gauge wires cemented to cantilever arms to make breathing measurements. The strain gauge, sensitive to airflow, works as part of a bridge circuit to measure the breathing flow, rate, and volume with extreme accuracy. An alternate device for making breathing measurements is this same strain gauge mounted in a chest band. This device responds to the alternate contraction and expansion of the chest rather than directly to the airflow. It has the disadvantage of possibly giving false readings when actuated by body movement. On the other hand, it does not encumber the subject's mouth. The mouth instrument is shown at top right.

EKG and heart-rate measurements would be taken in space in much the same manner as on the ground. Electrodes would attach to key parts of the body and lead to an electrocardiograph amplifier. A primary consideration in making this technique suitable for space flight is the development of special electrodes that can be worn for extended periods of time. The solution appears to be a layer of silver adhesive paint applied directly to the cleaned skin, a fine mesh wire placed over the paint, and a second layer of paint placed over and through the mesh. Such electrodes for EKG and heart rate are shown on a subject in the fourth photo on this page.

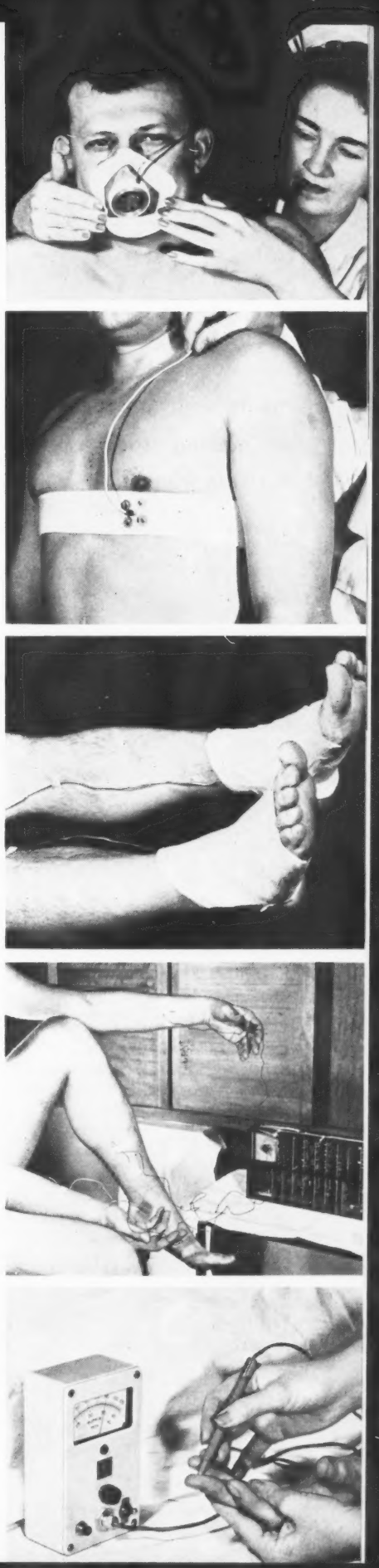
Miniaturization techniques became useful in the development of a device to take heart sounds—a small piezoelectric ceramic microphone mounted in a chest band and placed directly over the heart, much the same as a stethoscope in general practice.

Deviates from Standard Techniques

The device developed for taking systolic blood pressure deviates in concept from standard techniques more than most of these instruments. It employs an occluding rubber cuff placed around the finger. A sensor picks up the volumetric changes at the finger tip due to the pulsations of blood. Pulsations, after proper amplification, operate a pneumatic system which inflates the cuff. While the pressure in the cuff is below the systolic pressure, the pulsations are picked up and amplified.

In principle, this method is related to the arm-occluded cuff used standardly. However, automatic cycling and the use of the finger rather than the arm were specifically developed for space medicine applications. That is, the instrument does not encumber the subject and does not require an attendant to operate it. The basic design and development of this instrument were done by the Medical Electronics Development Co.

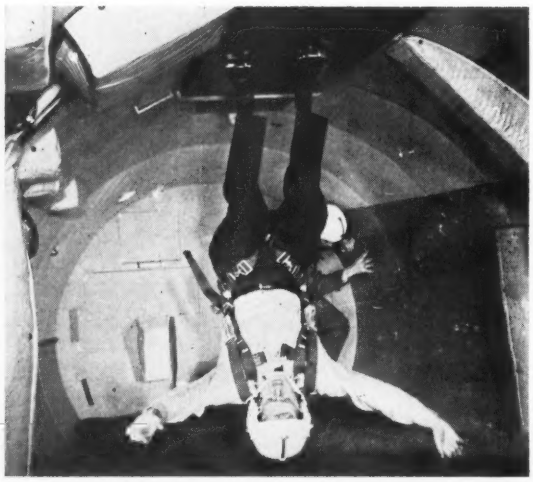
The measurement of galvanic skin response falls more into the psychological category, as changes in skin resistance are already accepted as a means for diagnosing mental reactions. The device for measuring GSR employs electrodes, again utilizing a stainless-steel abrasive base. But, since it would (CONTINUED ON PAGE 42)



Instruments devised by Gulton for key measurements include (from top) respiration rate and depth transducer over mouth and nose; ceramic chest microphone for taking heart sound; electrodes protected by ankle spats to take galvanic skin response (GSR), an index to psychological reactions; painted-on electrodes for taking EKG and heart rate; and a novel electronic (bead thermistor) contact thermometer for making direct, instantaneous reading of skin, rectal, and oral temperature. The design of these instruments aims at leaving the space pilot unencumbered.

Keeping your feet on the ground —in space

AF Aero Medical Lab experiments with magnetic shoes aim at making space pilots mobile but safe from sudden acceleration



An Aero Medical Lab experimenter wearing magnetic shoes makes his way down soft-iron walkway in C-131B aircraft during weightlessness run.

Experimental shoes: Alnico magnets on each shoe give static pull of 20–25 lb on soft-iron walkway.

HOW WILL a man weightless in space tell what is up, keep himself in one spot under vehicle acceleration or small forces imparted by moving objects, and walk in a controlled, directed fashion as he does on the surface of the earth? These questions and many others related to them must be answered in planning an orbital station in space.

Magnetic shoes and an "up" sign could supply the answers.

Members of the WADC Aero Medical Lab's crew stations section have designed and tested magnetic shoes to investigate problems of orientation in the weightless stage, criteria for a space crew selection program, and design requirements for space cabin equipment, such as handrails, walkways, controls, displays, etc.

The photos on this page show a pair of AML magnetic shoes and how they are used in weightlessness experiments in a C-131B transport aircraft.

The sandals consist of alnico magnets loosely bolted through foamrubber shims to aluminum soles. Each sandal gives a static pull of 20–25 lb on the soft-iron plate used as a walkway.

The experimenter found he could walk in a normal fashion in the sandals during weightlessness, his toe holding well until pulled loose and his heel rotating easily. He was pleasantly surprised to discover that his down-to-earth shoes induced the feeling that he was rightside up, and the pilots, poor fellows, were flying upside down. This subjectivity in space orientation was noticed previously by an experimenter crawling between the floor and ceiling of the C-131B in a weightlessness run.

The AML crew section, encouraged by experiments of this kind, are now studying the ratio between force applied on a weightless object and the object's holding force—what they call "skating" index, with reference to walking motion you get when holding force is too small.

For a man who wants to walk in a powered orbital vehicle, magnetic or some other adhesive shoes may need a skating index of 6 or so, which would provide a 2-g safety factor in a 4-g maneuver. This would necessitate strong magnetic shoes. Strong permanent-magnet shoes in turn would make the person who wears them do considerable work in moving about.

The crew section is therefore planning experiments with shoes having electromagnets, which will allow adjusting the holding force. The heat dissipation problem with electromagnets has lent this study the name "Project Hotfoot."

But these are serious experiments. Every movable object in a manned spacecraft will have to be given the appropriate skating index for the craft's maximum emergency acceleration. The simple experiments made thus far suggest the variety of careful engineering needed.—**J. N.**

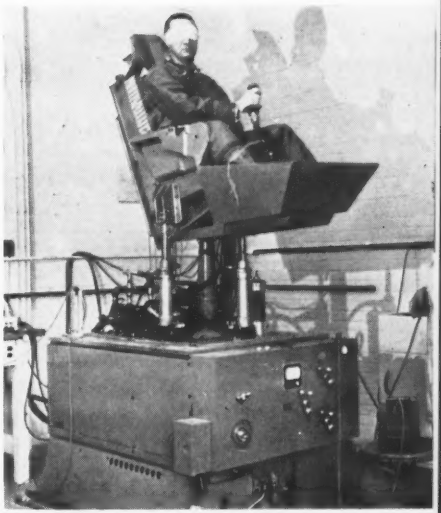
M/Sgt. George Post prepares to leave research capsule floating in WADC testing pool after three-day simulated lost-at-sea expriment as Col. John P. Stapp, ARS president, lends a hand. Tests of this kind will provide valuable information on how to keep alive spacemen whose capsules come down at sea.

Preparing for manned spaceflight

The engineers cope with problems from comfort to emergency escape as plans to put man into space take the form of design and tests

Subject wearing AF MC-2 full pressure suit tries out prototype net system designed to provide support during accelerations associated with rocket-powered flight at high altitudes.

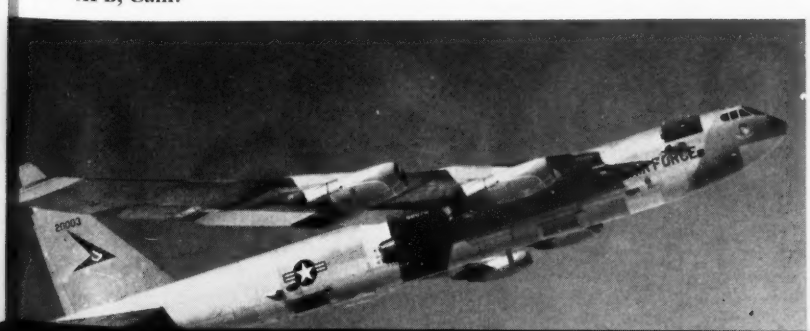
Sam Space Jr., one of a small group of monkeys now being trained at AF School of Aviation Medicine for space research work, looks pensive as he tries out model seat. Animal experiments are conducted under American Medical Assn. rules for humane treatment.



Project Mercury candidate balances the equilibrium chair at WADC in one test used to select prospective space pilots.

AiResearch Mfg. Div. of Garrett Corp. has developed this 5-lb animal capsule designed to carry mouse into orbit. John A. Potter, in charge of development, points to copper tubing used to cool circulating oxygen for the capsule.

X-15 takes to the air in captive flight test, nestled under wing of B-52 mother aircraft. Experimental rocket ship is undergoing tests at Edwards AFB, Calif.



A model of the Mercury capsule rides in Langley Research Center's full-scale wind tunnel ready for tests of lift, drag, and static-stability characteristics.

Progress on Project Mercury

In full swing, the design and testing of the Mercury capsule shows good progress on emergency-escape, flight, deceleration, and impact dynamics

THE MERCURY Project (outlined in the February 1959, ASTRONAUTICS, page 30) appears well on the way to being ready for freeflight testing of the operational system early this fall. NASA reports significant progress in testing the escape and terminal phases of flight with full-scale models; stability, pressure distribution, and heat transfer on small and large models of the capsule over the full velocity range; and impact on both water and ground. The accompanying photos show aspects of this testing.

Testing of the escape system—the pylon-mounted rockets to lift the capsule off the Jupiter rocket booster should it fail early during launching—has included determination of proper alignment of the escape-rocket nozzles, deployment of the parachute, and dynamic forces on the capsule with full-scale models at NASA's range at Wallops Island, Va.

Air-drops of full-scale 2-ton models of the capsule at Wallops Island also tested the terminal phase of flight to determine optimum altitude for parachute deployment in normal recovery, reliability of the parachute system, motion during descent, and impact forces on land and water. These tests began late last fall, after methods for dropping the capsule from a C-130 Hercules transport aircraft were developed.

One-ton "boilerplate" model of Mercury capsule heads skyward in NASA test of escape mechanism at Wallops Island, Va. Triple nose rockets spewing flames are designed to lift capsule off basic missile stages should something go wrong during launching attempt.

Langley Impact Tests

At nearby Langley Research Center (see October 1958, ASTRONAUTICS, page 21), laboratory tests with models have shown that the present shape of the capsule's landing face allows safe water impact and entry. Also being tested there with instrumented models are several materials and arrangements for absorbing the shock of impact, among them plastics

and aluminum in honeycomb form and fibrous cellulose.

Behavior of the capsule during flight is being studied in the wind tunnels of NASA's Ames and Langley Research Centers, and the Arnold Engineering Center, Tullahoma, Tenn.

At Wallops, small rocket-launched models are subjected to the full velocity range to investigate tumbling characteristics, re-entry dynamics, and afterbody heating.

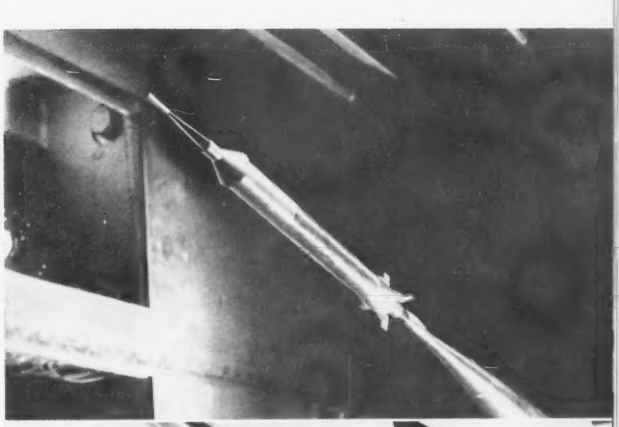
Determine Heat Transfer

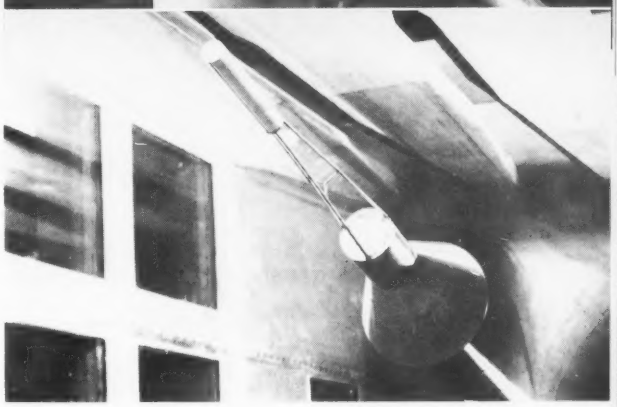
Langley tunnels have been used to determine heat transfer and pressure over the heat shield, dynamic stability, afterbody pressures, pressure distribution, lift, and drag. The Langley tunnels cover a velocity range from just a few miles per hour to Mach 18 (11,000 mph).

At Ames Research Center (see September 1958, ASTRONAUTICS, page 46) studies have been made of panel flutter, pressure distribution, heat transfer, static and dynamic stability, lift, and drag in the Mach 0.6-15.3 range.

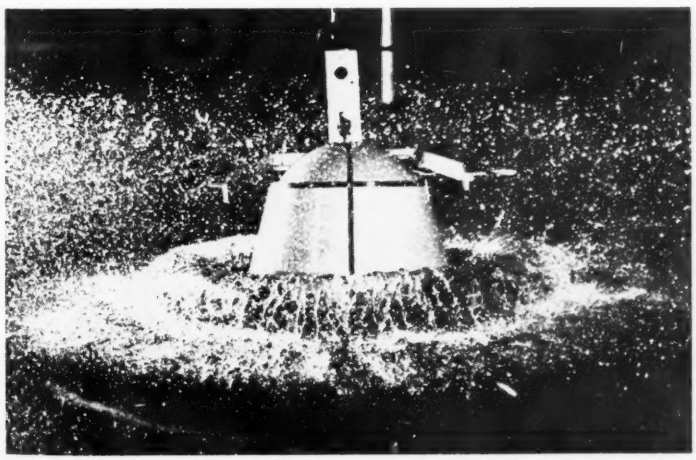
Lift, drag, stability, and pressure-distribution studies between Mach 0.5 and Mach 20 (13,000 mph) are scheduled at Arnold.

NASA's Space Task Group, directed by Robert Gilruth, administers the Mercury program from headquarters at Langley Research Center.—**J.N.**

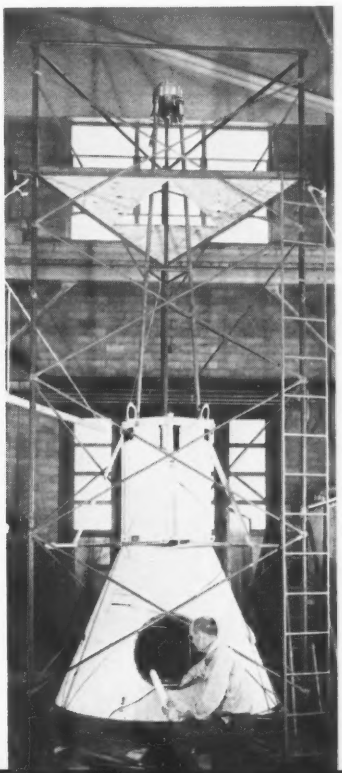




Extensive wind tunnel studies in the Mercury program include transonic testing of a model Jupiter booster plus capsule (top) and capsule plus emergency-escape system (above) in Langley's 8-ft transonic wind tunnel.



Here, a wooden mockup of the Mercury capsule enters water in a laboratory impact test at Langley. Tests such as this showed the present entry face of the capsule safe for impact and water entry.



Full-scale models have tested the escape and terminal phases of Mercury capsule flight. This photo, in which can be seen the pylon-mounted escape rockets, shows the full-scale model used in the first test of the escape system at NASA's Wallops Island range.

Relatively new, the study of materials behavior under space-equivalent conditions calls for high vacuum systems of advanced engineering design and performance. NRC's Research Div. developed this unit, which goes below 10^{-9} mm Hg (simulated density of space 400 miles above earth), both to study materials and to evaluate new methods for producing ultrahigh vacuum. Such units may also adapt to simulators of solar radiation, particle bombardment, and the infinite heat sink of space.

Behavior of materials in space

Alterable, often drastically, by the harsh and subtle powers of space, familiar materials require extensive new study for proper application in space vehicles

John C. Simons Jr. is director of NRC's physics research and vacuum technology program, having responsibility for advanced instrumentation, electron bombardment furnaces for melting refractory metals, ultrahigh vacuum technology, simulation of the space environment, and long range development of new products. After receiving a Ph.D. in physics from MIT in 1950, Dr. Simons directed control system research and simulation in Westinghouse's program for the Nautilus submarine, and later directed research on analog computers and fire control systems for several years at MIT. Among his professional associations, he is a member of the advisory panel to the NBS Radio Standards Div.

By John C. Simons Jr.

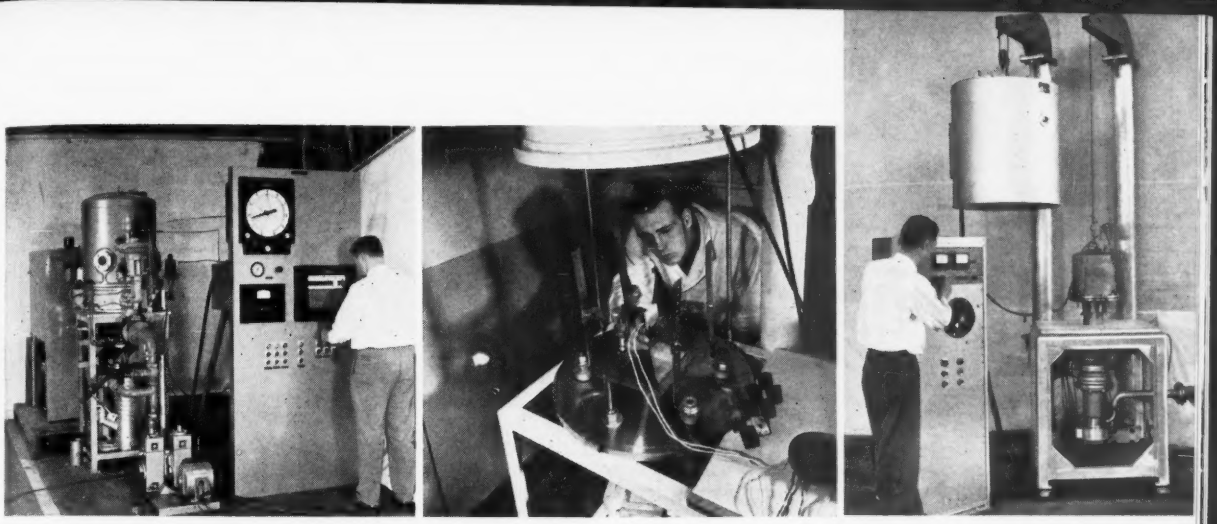
NATIONAL RESEARCH CORP., CAMBRIDGE, MASS.

SPACE vehicles and their materials will be subjected for extended periods to an environment radically different from that at the earth's surface. The space environment has such known properties as greatly reduced density, intense solar radiation, high energy electromagnetic radiation, charged particles, and meteorites.

A great deal of information exists about the properties of materials in the earth's normal atmosphere, but many aspects of the behavior of materials in outer space are unknown. The effect on materials of these environmental factors cannot readily be determined by extrapolating existing data. Thus there is a need for determining the behavior of materials under space conditions. Knowledge of the behavior of materials will provide a basis for the design of space vehicles, and will also be useful in the design of extreme-altitude, sustained-flight aircraft, boost-glide vehicles, and ballistic missiles.

The high cost of preparing and launching probe vehicles and the complexity of experiments conducted remotely make it desirable to simulate space-equivalent conditions for study in the laboratory when this can be done with confidence. The table on page 84 summarizes some of the conditions of the space environment that might be simulated.

Effects of the space environment on various materials, however, have to be interpreted in the light of the intended application. A



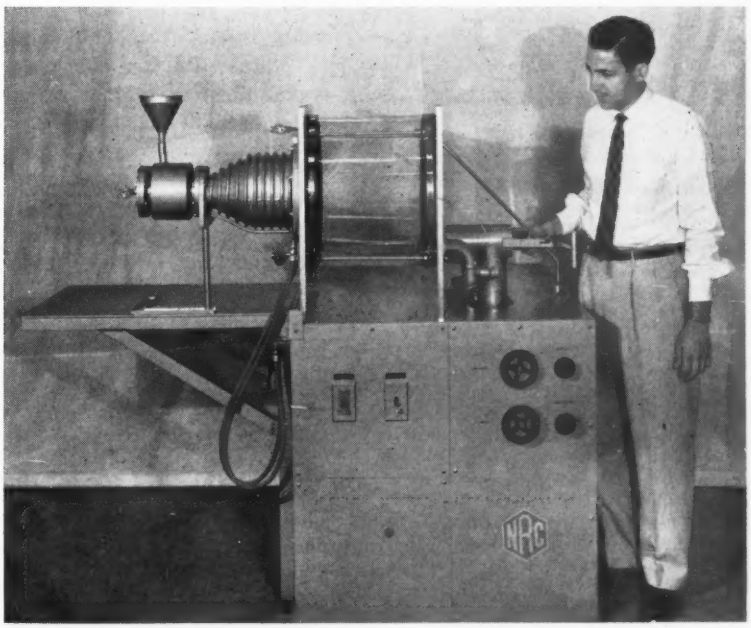
First, this NRC chamber, which has automatic altitude-cycling controls, tests electronic components at simulated altitudes up to 60 miles. Next, NRC vacuum unit (10^{-6} mm Hg routine) for testing materials at controlled temperatures receives a plastic specimen; the unit screens materials for testing at simulated altitudes up to 400 miles. Next, a small ultrahigh (10^{-9} mm Hg) vacuum unit for testing semiconductor and surface properties; the large tank suspended is a bakeout oven that drops over the vacuum unit.

list of applications might include the following:

1. Structural members
2. Walls and compartments
3. Antennas
4. Seals and sealants
5. Lubricants
6. Electrical conductors and insulators (both low and high frequency)
7. Radiation windows (optical, infrared, ultraviolet, nuclear)
8. Radiation reflectors, absorbers, and shielding

The magnitude of the effect of space conditions on the physical properties of various materials varies considerably with the type of material and the nature and "intensity" of the condition imposed. In addition, if the material is subjected to two or more conditions simultaneously, which is generally the case, the individual effects may be compounded in a complex manner.

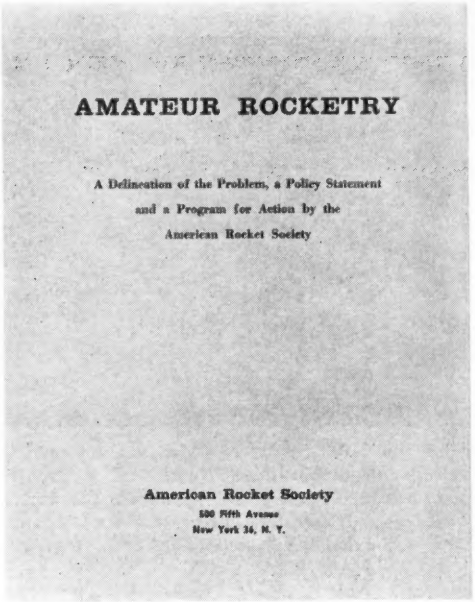
For example, assume that a length of electronic cable is insulated with a plastic coating which tends to lose its plasticizer in the near vacuum of space, causing it to become brittle, crack, and short out an important circuit. Since the plasticizer is volatile, its rate of loss is also probably a function of temperature. If we expose the (CONTINUED ON PAGE 84)



This small NRC laboratory chamber will test an ion engine in the pressure range 10^{-5} to 10^{-6} mm Hg (100 to 125 miles altitude). The ion engine mounts on the right of glass viewing tube, here shown sealed for a vacuum test. A liquid-nitrogen-cooled condensing unit removes ion engine discharge.

ARS on amateur rocketry

Society's Board of Directors documents reasons for its strong opposition to experimental work by amateurs with explosive propellants in report based on study by Southern California Section


AMATEUR ROCKETRY
A Delineation of the Problem, a Policy Statement
and a Program for Action by the
American Rocket Society
American Rocket Society
500 Fifth Avenue
New York 36, N. Y.

By James J. Harford

EXECUTIVE SECRETARY, AMERICAN ROCKET SOCIETY

John I. Shafer

Committee Chairman

The full-scale report on amateur rocketry released last month by ARS is due in large measure to the work of the Southern California Section's Ad Hoc Committee on Amateur Rocketry, headed by John I. Shafer of JPL, who has been engaged in rocket research for more than 20 years. A 1938 Purdue grad, he worked for Hercules Powder Co. on the development of solid propellants from 1940 to the end of WW II. Then, after a brief stay with Aerojet, he joined JPL, where he has remained for the past 11 years as research engineer, and later, chief in the Solid Rocket Section. He is at present propulsion staff engineer to the Lab director.

THE AMATEUR rocketry problem has been met head-on at last. A 76-page report, entitled "Amateur Rocketry," based on a study conducted by the ARS Southern California Section, defines the Society's policy and issues a call for action to its 47 Sections and 35 Student Chapters, as well as its 13,000 members throughout the country.

The magnitude of the problem is impressive enough. The report estimates that there are about 10,000 experimenters in the 10- to 20-year-old age group actively engaged in mixing propellants and in fabricating and flight testing small rockets. However, it estimates that there are in addition perhaps 250,000 passive and occasional participants. There is speculation as to whether the movement is at its peak, whether it is tapering off, or whether it is just beginning. However, chances are that, with the summer months coming up, it will blossom out again, so the report is especially timely.

The statistics on accidents are arresting enough—84 children and two adults maimed or wounded in one 6-week period, according to one admittedly incomplete study. But the fact is that hundreds of thousands of hours are being spent on a pastime which all too often is not only deadly, but also produces a very questionable scientific yield. It all adds up to a colossal waste of time for young people who could be making useful contributions to their own scientific development and, in some cases, even to the fund of scientific knowledge, as witness some of the remarkable projects in the Westinghouse Science Talent Contests.

Chief architect of the report is John I. Shafer of the Jet Propulsion Laboratory at CalTech, long-time rocket professional. Shafer was named chairman of an Ad Hoc Committee of the Southern California Section by Section President G. Daniel Brewer in mid-1958. On the committee were G. M. Cunningham of Olin-Mathieson, G. E. Pelletier of Aerojet, W. C. Strang of Convair-Pomona, and H. L. Thackwell Jr. of Grand Central Rocket Co. The group's charter directed it to recommend a policy that could be adopted by ARS on amateur rocketry and to determine courses of action to be taken to assist in reducing the problem.

The report covers in fascinating detail some of the early experimental work done in both liquid and solid rockets, particularly the work done by JPL in the 1940–43 period. The point of this section of the report is to show how truly hazardous working with so-called "reliable" and "simple" rockets is, even when professionals are involved. Here is one excerpt:

"The molded powder charge of the early JPL investigators performed reproducibly and looked very promising until stored. Then it was found that normal fluctuations in temperature would tend to crack the charge or to separate powder increments and result in explosions. It was finally concluded that any crystalline-based propellant (which includes our amateurs' zinc-sulfur mixtures) inherently would not perform reliably after storage. Eventually this dilemma was resolved by development of a propellant based on an oxidizer of potassium perchlorate mechanically dispersed in (CONTINUED ON PAGE 108)

Excerpts from President's Foreword to ARS Amateur Rocketry Report

"The AMERICAN ROCKET SOCIETY *reaffirms its strong stand in opposition to any amateur experimentation whatsoever with rocket propellants or rocket propellant materials of any kind."*

Motion unanimously approved by ARS Board, January 29, 1958

Preparation of this publication—the first full-scale investigation of amateur rocketry—was undertaken, based on the report of an Ad Hoc Group of the Southern California Section of the AMERICAN ROCKET SOCIETY, because of growing indications that hazardous rocket experimentation by amateurs has become a nationwide problem with serious, and often tragic, overtones.

The scope of the amateur rocketry problem, and its implications, have never been more clearly delineated than in these pages. The ARS program for combating the problem is designed to eliminate accidents and deaths from live rocket experiments by the straightforward method of eliminating the experiments. ARS doesn't pretend to be anything but firmly negative on this aspect of the problem because negative action is loudly called for—unpopular though it may be in some quarters.

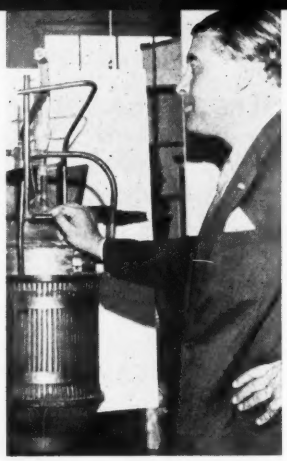
The Society does, indeed, regard the *positive* encouragement of young people to study rocket and spaceflight principles as equal in importance. But the investigation conducted by the Society clearly shows that the development of the science of rocketry is *not* served by amateur experimentation. The somewhat debatable loss in opportunity for intellectual development which might be suffered by forgoing experimentation is small compared with apparently unavoidable and appalling losses of eyes, fingers, and lives.

The ARS is providing the leadership for a positive educational program which will seek to mobilize the Society's more than 13,000 members through Education Committees in each of its 47 regional Sections and 35 Student Chapters at colleges and universities. The program is already underway in some Sections.

One strong word of caution to those who get this report: It is *not* intended as a guide for amateur rocketry clubs. *The report should therefore be kept out of the hands of experimenters, and especially teenagers, because illustrations of dangerous practices and formulas for hazardous propellants are included as examples.*

A 16-page brochure, based on the report, will be issued in the near future by the Society for widespread dissemination among amateur rocketeers, and, even more important, their parents and teachers, who are unaware of the grave dangers attendant upon attempts to build and fire homemade rockets.

John P. Stapp
President, AMERICAN ROCKET SOCIETY



Von Braun inspects early Goddard rocket.

Von Braun tribute to Goddard

ABMA development chief praises "boyhood hero" as an example of the type of "visionary dreamer" who has contributed so much for the benefit of mankind at dedication of Goddard Wing at Roswell Museum

WERNHER von Braun, director of the ABMA Development Operations Div., in his address at the ceremonies marking the dedication of the Robert H. Goddard Rocket and Space Wing of the Roswell (N.M.) Museum and Art Center, praised the American rocket pioneer as one of those "visionary dreamers" who have accomplished so much for the edification and benefit of mankind.

Referring to Dr. Goddard as "my boyhood hero," Dr. Von Braun, in a brief but obviously heartfelt tribute, noted that the U.S. today would undoubtedly enjoy unchallenged leadership in space exploration if adequate support and recognition had been accorded the man who did so much to make today's accomplishments in the fields of rocketry and astronautics possible.

Robert H. Goddard

The full text of Dr. Von Braun's address follows:

"I am honored to participate in the dedication of the Robert Hutchings Goddard Rocket Collection of Roswell Museum and Art Center and doubly honored to be invited to discuss the contributions of my boyhood hero, Dr. Goddard, to science, although this is indeed difficult, because the towering importance of his pioneering efforts is impossible to evaluate at this stage of the art.

"However belated, the recognition accorded to Dr. Goddard is eminently deserved. Like other scientists working in novel and little understood fields, venturing into unknowns fraught with hazard, he did not live to see the fruits of his successful work. Now he belongs to the world of space.

"Rocketry in this country and abroad owes a great debt to his vision. While he contributed basic knowledge essential to further progress in his field, he also demonstrated an extraordinary ability to translate theory into operating rocket systems. In the light of what has happened since his untimely death, we can only wonder what might have been if America realized earlier the implications of his work. I have not the slightest doubt that the United States today would enjoy unchallenged leadership in space exploration had adequate support and recognition been provided to him. It is to the great credit of both institutions that the Guggenheim Foundation and the Smithsonian Institute gave at least a part of his continuing effort some financial backing and appropriate professional recognition.

"He was engaged in studies of high altitude research rocket design while still a student in 1908. In 1919, he published a monograph titled 'A Method of Reaching Extreme Alti- (CONTINUED ON PAGE 82)

Mrs. Robert H. Goddard, widow of the American rocket pioneer, poses with former employes of Dr. Goddard near the Goddard launching tower, now installed at the Roswell Museum. Left to right, Albert S. Campbell, Sidney L. Squire, George Bode, Calistro Sanchez, Lowell N. Randall, Mrs. Goddard, Charles W. Mansur (hidden) and N. T. Ljunquist.

Roswell Daily Record photos by John P. Foster

It's a Goddard year

ARS announces plans for Goddard Memorial at Worcester as Goddard Wing of Roswell Museum opens with impressive ceremonies and NASA names its new Greenbelt facility the Goddard Spaceflight Center

By Irwin Hersey

1959 is fast turning into a Robert H. Goddard year, as honors come fast and furious to the great American rocket pioneer—almost as if to make up for the appalling lack of recognition accorded him in this country during a lifetime dedicated to rocket and astronautical research.

Already the recipient of the first IAS Louis W. Hill Space Transportation Award earlier this year, Dr. Goddard had additional honors galore heaped upon him in April. Among them were:

- Official announcement of AMERICAN ROCKET SOCIETY plans to establish a full-scale Goddard Memorial at Worcester, Mass., near the site of the world's first successful liquid rocket flight in 1926.
- Dedication of the Robert H. Goddard Rocket and Space Wing of the Roswell (N.M.) Museum and Art Center on April 25, close by the Mescalero Ranch area where Dr. Goddard conducted important high altitude rocket experiments in the '30's.
- Announcement by NASA that its new space projects center at Greenbelt, Md., will be named the Goddard Space Flight Center.
- Dedication of a new Goddard Memorial Exhibit on April 29 at Worcester Polytechnic Institute, where Dr. Goddard was a student and where he performed his earliest rocket experiments.
- Announcement that the Air Force Academy was initiating the Goddard Award, to go each year to the student with the highest grades in mathematics.
- Announcement that the first full-scale biography of Dr. Goddard, using a good deal of previously unpub- (CONTINUED ON PAGE 78)

Mrs. Goddard formally opens the Robert H. Goddard Rocket and Space Wing of the Roswell Museum as (left to right) Wernher von Braun, Under Secretary of the Army Hugh M. Milton II and Mrs. Milton, and Robert Merriam, deputy assistant to President Eisenhower, look on.

Three Astronautical Pioneers—3

Hermann Oberth
from my life

"This is the goal: To make available for life every place where life is possible. To make inhabitable all worlds as yet uninhabitable, and all life purposeful."

—HERMANN OBERTH

Background

Any series of articles devoted to the pioneers of astronautics would be incomplete without reference to Hermann Oberth, whose slim pamphlet, "Die Rakete zu den Planetenräumen" ("The Rocket into Interplanetary Space"), published in 1923, fired the imagination of the early European rocket experimenters and was directly responsible for the formation of the German Rocket Society in 1927 and indirectly, a few years later, of the AMERICAN ROCKET SOCIETY.

This autobiography of Prof. Oberth, now living in Feucht, near Nuremberg, Germany, was specially written for ASTRONAUTICS and, like the previously unpublished autobiographies of two other great astronautical pioneers—the American, Robert H. Goddard, and the Russian, Konstantin Tsiolkovskii—found in the April and May issues, offers an insight into the motivating forces which led to his interest in spaceflight.

A full-scale autobiography of Prof. Oberth was published in Germany last year, and is expected to be available in an English translation in the not-too-distant future.

While the name of Hermann Oberth has already won enduring fame, the work begun by Prof. Oberth some 40 years ago is being continued by a second-generation Oberth, his son Adolph, who recently joined Aerojet's Solid Rocket Plant in Sacramento, where he is engaged in research work on high energy propellants.

I WAS born on June 25, 1894, in the town of Hermannstadt in Transylvania, which, formerly an independent country, was part of Hungary at that time. My father, since 1893 an assistant surgeon at the Franz Joseph-Buergerspital (i.e., the Municipal Hospital of Hermannstadt), in 1896 became director and chief surgeon in charge of the County Hospital in Schässburg, Transylvania.

At that time, this was still a somewhat patriarchal town of some 11,000 inhabitants. It wasn't until 1902 that Schässburg acquired water supply mains and electric lights. In 1904, the telephone became available, with only 37 subscribers reported to the telephone service in the first three years. Even so late as the 1930's the "Burg"—the ancient part of the town, situated on a hill and surrounded by a wall—was without a sewer installation. Cesspools in the houses were emptied by gypsies and discharged into the river "Kockel" flowing past the town. The uncovered outlets from the sinks ran into the narrow streets, which were paved with round headstones. A rather bad smell spread over the town in summer when there had been no rain for extended periods.

The hospital and our home were situated somewhat outside the town on Michael Albert Street, which formed part of the highway leading from Budapest through Kronstadt to Bucharest. Our home, adjacent to the hospital, had its sewer installation, and was thus in a more comfortable condition. Our street was built like a causeway, and macadamized but not asphalted or tarred. In summertime the road was dusty and turned boggy when it rained, so that it would hardly have met the requirements of modern motor car traffic. Anyway, at that time it was used only by carts and carriages drawn by oxen or horses and later cyclists when bicycles made their first appearance. It was in 1904 when I saw the first automobile. Because of the dust, my father then acquired a cottage bordering a

wood, called the Siechhofwald. From there we had a wonderful sight of our town, which was beautifully situated.

It was the railway station at the foot of the hill which interested me particularly. The railway station was about the only thing linking our town with the big world of industry and engineering—apart from six small local factories, of which our citizens had been rather proud. The biggest of them employed 150 and the others from 10 to 60 workmen.

Camels are said to discover new sources of water when they are thirsty. Maybe something similar happened to me, for I had been eager for engineering and progress. I had been particularly interested in anything moving and not requiring it be driven by men or drawn by animals—a means by which one could travel along, the quicker, the better. I designed fantastic projects for locomotives, airplanes, and spaceships. At the age of eleven, I received from my mother as a gift the famous books, "From the Earth to the Moon" and "Travel to the Moon" by Jules Verne, which I had read at least five or six times and, finally, knew by heart.

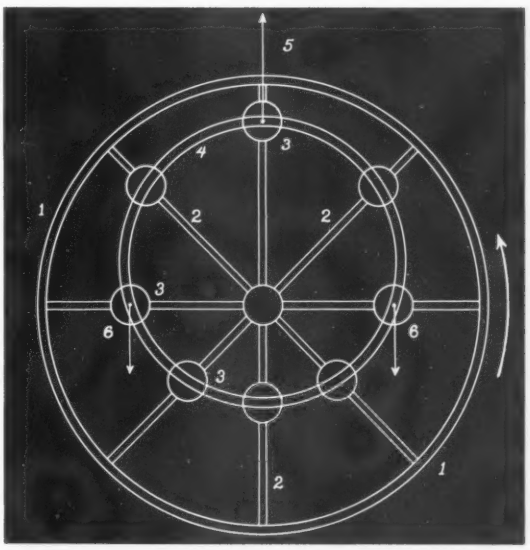
Realized Verne Was Wrong

Even though I had taken a lot of interest in these stories, I realized already at the age of twelve that shooting a missile out of a giant gun with the travelers inside, as Verne imagined for spaceflight, would not work. Even if it would have been technically feasible to produce such a gun, the travelers inside the missile would have been crushed without pity by the enormous acceleration.

With my knowledge in mathematics, still rather deficient at that time, I was able, however, to find out so much at any rate, that the escape velocity of 11,000 m/sec (about 25,000 mph) was roughly correct. At school we had learned the laws of gravity, so that I could derive by myself at least the formula $v = \sqrt{v_o + 2\,gh}$. Furthermore, our young and clever teacher in physics, Ludwig Fabini, managed to make us understand that the attraction of gravity exerted by the earth would decrease in proportion to the square of the distance from the earth center. So I divided the trajectory of the missile up to the moon into sections—smaller ones down toward the earth and larger ones up toward the moon—assuming for the gravitational acceleration in each section a mean value. For the first two sections I took the final velocity of the preceding one as the initial velocity of the next one, and finally I discovered that for the rest it was for me simpler to calculate $v = \sqrt{2g_1\,h_1 + 2g_2\,h_2 + 2g_3\,h_3 + \ldots}$ so that I had to extract the square root only once.

Seeing that a gun did not work, I set to thinking on other solutions or (CONTINUED ON PAGE 100)

This simple and austere cover lent ironic understatement to Hermann Oberth's history-making study of rocketry and spaceflight, "Die Rakete zu den Planetenraumen."



Hermann Oberth, spurred by his boyhood dream of spaceflight, designed this "levitating" wheel as a young teenager, but soon rejected the notion of force unbalance which led him to suppose it would rise. As he humorously remarks, "Every year I am approached by eight or ten inventors with what amounts to the same scheme."

NASA budget up for fiscal 1960

Funds for R&D rise from $225 million to $333 million . . . Satellite, manned spaceflight, high energy fuel, big engine programs boosted

NASA's R&D budget will rise sharply during fiscal 1960, going to $333,070,000 from $225,369,532 the previous year. Largest increases will be in the development of earth satellites, the million-pound-thrust single-chamber engine, manned space vehicles, high energy fuel systems, and tracking and data acquisition.

That the day of the small satellite package is over is indicated by the fact that the Vanguard program, for which $25.5 million was spent during fiscal 1959, will have run its course at the end of this fiscal year, with no funds allocated for fiscal 1960.

Two new areas, for which no funds were allocated last year, appear on the NASA R&D budget, revealed in the course of testimony by NASA officials before the Senate Committee on Aeronautical and Space Sciences, for the first time. These are orbiting space laboratories, for which $2 million has been allocated, and space rendezvous techniques, with a $3 million allocation.

The largest single boost in the fiscal '60 budget is for development of the million-pound-thrust single-chamber engine, with allocations rising from $12 million in fiscal 1959 to $30.2 million.

NASA Research and Development Programs, Fiscal 1959–1960

Program	Fiscal 1959	Fiscal 1960 (Estimated)
Aircraft, missile, and spacecraft research:		
Support of NASA plant	$ 338,800	$ 16,670,000
Support of JPL plant	8,156,500	8,156,500
Research contracts	5,500,000	8,200,000
Scientific investigations in space:		
Sounding rockets	5,000,000	10,000,000
Earth satellites	44,000,000	61,800,000
Lunar probes	20,021,750	24,043,500
Deep-space probes	16,000,000	22,500,000
Vanguard program	25,541,282	—
Satellite applications investigations:		
Meteorology	3,400,000	15,000,000
Communications	4,700,000	13,000,000
Space operations technology:		
Manned space flight	58,411,200*	70,000,000
Space rendezvous techniques	—	3,000,000
Space propulsion technology:		
Solid fuel rockets	700,000	3,000,000
High energy fuel rockets	7,000,000	17,000,000
1-million-pound thrust single-chamber engine	12,000,000	30,200,000
Nuclear rocket engines	8,500,000	8,000,000
Space engines	300,000	3,000,000
Auxiliary power units	500,000	3,000,000
Space systems technology.		
Advanced vehicle systems	500,000	1,500,000
Booster recovery systems	500,000	1,500,000
Orbiting space laboratories	—	2,000,000
Supporting activities:		
Tracking and data acquisition	4,300,000	11,500,000
Total research and development	225,369,532	333,070,000

* Includes estimated $20,750,000 supplemental funding.

Mosaic of Project Hugo photos gives this 1000-mile-wide view of a weather front over the Atlantic Ocean from an altitude of 86 miles.

The view from above

Project Hugo provides another link in worldwide meteorology and gives a glimpse of the view of earth awaiting man in space

LAST DECEMBER, a camera package launched with a Nike-Cajun rocket from NASA's range at Wallops Island, Va., reached an altitude of 86.25 miles and took photos of a weather front and its associated cloud formations over the Atlantic Ocean. Pieced together as a mosaic, with a sweep of some 1000 miles, these pictures afforded meteorologists the first bird's-eye view of the kind of weather system they have been making predictions about for over 40 years with Norwegian front theory. The mosaic also gives an impression of the majestic view of earth awaiting man in space.

The pictures were taken as part of Project Hugo (Highly Unusual Geophysical Operations), an Office of Naval Research program for research in meteorology aimed at improving the accuracy of weather prediction. This program has the assistance and cooperation of Navy BuAer, the U.S. Weather Bureau, and NASA.

The Project Hugo camera and instrument system was designed and built by the Physical Science Lab of the New Mexico State Univ., Las Cruces, N.M., under contract to ONR. It was designed specifically to photograph weather frontal systems from very high altitudes over ocean areas where there are no permanent weather stations.

The Hugo payload consisted of instruments, payload separation and tracking devices, and a recovery system. The instrument package contained two NRL-designed 16-mm movie cameras, a radar beacon, a homing transmitter, primary and secondary programming devices, nose-cowl jettison equipment, a drag parachute, a booster-rocket separation ring, four blocks of dye as a sea marker, and power supplies. The standard Nike-Cajun rocket served as booster.

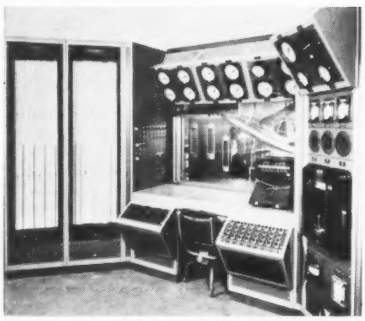
Launching Had Three Objectives

The launching of the Hugo system last December, the first over water, had three objectives: To obtain high altitude photographs of a weather front, to evaluate the Hugo recovery system, and to check the performance of the Nike-Cajun rocket with the Hugo camera and instrument package.

The flight nicely fulfilled these objectives. Launching and stage separation went off without a hitch. The payload, descending some 200 miles off the Virginia shore, was easily tracked and quickly recovered by one aircraft and one destroyer despite heavy weather.

The pictures obtained with the Hugo system are the clearest and technically most rewarding yet taken of a weather front with a high altitude rocket. Project Hugo has thus made an important contribution to the growing technology of worldwide weather measurement and prediction.—**J.N.**

Ready for the Test



This instrumentation, looking better than what the science-fiction movies offer, controls the testing of small equipment at the Stratos Div. of Fairchild Engine and Airplane Corp. Sleek modular Emcor cabinets are designed to bring all equipment and instruments within easy reach of one operator.

Mercury Astronauts

(CONTINUED FROM PAGE 22)

have an important role in engineering and scientific development of the Mercury vehicle, suborbital buildup missions and, finally, manned satellite flight.

All are married and have children (and had the approval of their wives to volunteer); all expressed the hope that they would go into space, and all had the conviction that they would come back safely.

Selection of the astronauts got underway several months ago. Since many of the conditions expected in orbital flight are similar to those experienced by military test pilots, NASA went to this field to seek volunteers. More than 100 pilots were found to meet the general qualifications. Of these, 69 were interviewed, and 80 per cent volunteered for the assignment. After personal interviews, the list of candidates was narrowed to 32.

During the course of the selection program, NASA determined upon seven as the optimum number of Mercury astronauts, so that each would have a full opportunity to participate in all phases of the Mercury development program.

Immediately following their Washington interviews, candidates reported to the Lovelace Clinic in Albuquerque, N. M. for an exhaustive series of examinations. Each candidate spent $7\frac{1}{2}$ days and 3 evenings at the Lovelace facility.

General physical requirements were established by the NASA Life Sciences Committee. Since all those examined were active test pilots, it was not anticipated that any would be disqualified as physically unfit. Rather, degrees of physical soundness were obtained and evaluation was dependent upon a comparison of each man with his fellow candidates.

To establish a comparative yardstick, the Lovelace program began with a complete aviation and medical history and extended to the areas of hematology and pathology, roentgenology, ophthalmology, otolaryngology, cardiology, neurology and myology, general internal medicine, and related laboratory studies.

Special consultations were provided if indicated by the candidate's medical history or any of the general examinations. These examinations were given under normal clinical procedures, with the subject in a resting condition. To assess the candidate's abilities under load, Lovelace physicians developed a series of dynamic tests used for the first time in the Project Mercury selection process.

Capacity under load, or body efficiency, was determined from a correlation of the subject's physical competence with his pulmonary function, total body radiation count, specific gravity of the body, blood volume, water volume, lean body mass, and detection of tiny congenital openings between the chambers of the heart.

Results of the static and dynamic tests were recorded on special computing cards developed by the Lovelace Clinic for the astronaut program. These cards were mark-sensed so they could be read directly by the examining physician, and contain the candidate's complete aviation and medical histories and examination findings.

Psychological Tests

The next step in the selection process involved determination of the candidate's psychological make-up and estimation of his ability to cope with stresses expected in spaceflight.

This part of the selection process took into consideration previously developed studies made in anticipation of the need for a program to select and precondition pilots for extreme high altitude flights. The program was tailored to meet the specific requirements foreseen for orbital flight.

The Air Force, with the assistance of Army and Navy specialists, conducted psychological and stress measurements at the Wright Air Development Center Aeromedical Labs, Wright-Patterson AFB. The examinations were in the general areas of personality evaluation, behavioral sciences, stress and fatigue, accelerative forces, equilibrium and vibration, high energy noise, low barometric pressure, thermal stress, and anthropology.

A complex appraisal of both clinical and statistical test results went into the WADC evaluation of candidates. As in the case of the Lovelace examinations, results were not a matter of passing or failing, but instead were measures of how one candidate compared with all others.

Data from the Lovelace and WADC examinations were compiled and forwarded to the NASA Space Flight Activity at Langley Field, for the fourth and final step in the selection process. At Langley, a group representing both the medical and technical fields evaluated the previous examinations. The seven men ultimately selected were chosen as a result of physical, psychological, and stress tolerance abilities and because of the particular scientific discipline each represents.

Because manned satellite flight is without precedent, the seven Mercury astronauts will be pioneers not only in spaceflight but also in the development of a program which will determine qualities best suited for such special missions.

Medical Electronics

(CONTINUED FROM PAGE 27)

be impractical to tie down the wrists of the space pilot, the electrodes have been designed into a pair of modified ankle supports, similar in appearance to spats, as can be seen in the series of photos on page 27. With this approach, shoes or other suitable footgear can be used without disrupting the measurement.

An EEG is obtained with a sensing device that uses electrodes built into an elastic headband and placed so that the appropriate positioning—frontal, temporal, or parietal occipital—will hold as long as the head piece is put on correctly. The neutral electrodes in this sensor are built into earlobe clips.

These instruments require appropriate data-conversion circuitry and telemetering equipment. To solve these related problems, Gulton has devised a package of completely transistorized circuitry including a sensor conditioner, analog-to-digital computer, and transmitter. This equipment employs modular design, and is light and compact.

It is hoped that such medical instruments will help insure the complete success of man's first venture into space.

Kodak reports on:

60,000 inches per second without a break . . . electronics through joy . . . a nice material to coat with photographic emulsion

Contest

NEW: Kodak Linagraph 77 Paper. In one popular make of oscillograph (undoctored), it has recorded without a break a line written on it by a spot of light moving at 60,000 inches per second.

ALSO NEW: Kodak Linagraph 44 Paper, for any application of paper-eating oscillographs where extra blackness and contrast of the line are worth accepting one-fourth the speed of Linagraph 77 Paper.

Queerly enough this field, the very existence of which is probably unknown to 99% of the population, is one in which corporate giants manfully smite each other hip and thigh with a vigor that even Detroit would enjoy. Now that we have rearmed ourselves with the two magnificent weapons named above, the mere innuendo that the foe can even approach us in generating customer satisfaction will cause our nostrils to flare.

Technologically the problem reduces to the spreading of a superior light-sensitive emulsion in a superior manner on a superior paper stock thin enough to take longer recordings between reloadings and strong enough to stand stabilization processing. This widely used and rapid but rigorous machine method we had the honor to invent.

Anyone practicing paper oscillography would be cheating himself not to seize the opportunity afforded him (as a judge in the contest) to improve the appearance, readability, and reliability of the records he turns out. Either the Kodak dealer who regularly serves him or Photo Recording Methods Division, Eastman Kodak Company, Rochester 4, N. Y., can furnish all pertinent details about Kodak Linagraph 77 *and* 44 Papers.

TV—rugged and sophisticated

Loath to fight World War III in an ad (though this may not be a bad place to fight it, personal safety considered), we can only generalize from the concept that to place a living human eye at the payoff end of an intricate and talented optical device may be inconvenient and unwise. Where the environment is too violent for the eye, we have developed a knack for substituting a television camera.

This calls for cameras more sophisticated than those which read boxcar numbers in remote corners of railroad yards. We take pickup tubes (drinking deep draughts of the knowledge of their manufacturers, just as they are welcome to milk us when it comes to photography) and festoon the tubes with electronic circuitry, optical elegance, and precision-mechanical musculature—all neatly woven together. The whole we put in small packages. We can make the packages do their duty gracefully under 15 g's of shock and 145 db of acoustic energy in each octave to 20,000 cycles/sec for x minutes at 200°F or y hours at −65°F after z months of storage at −80°F.

How did we happen to get electronically involved? Well, the biggest part of our business has always been ways and means of presenting an image to the eye. Electronics engineers we have in goodly numbers on such projects as machines that take a very quick look at a Kodacolor negative and instantly reach a complicated decision on how to vary some colored light beams to bring the greatest joy to the

lady calling for her Kodacolor Prints. With what such machines cost, they have to work when you turn them on. Like virtue, reliability becomes its own reward. This viewpoint our electronics engineers must quickly acquire.

Another corps of Kodak electronics engineers bring to TV-systems development the experience of packaging radio transmitters and receivers to work inside artillery shells. This, too, we got into from catering to the public's photographic desires. The armed forces had figured that an outfit capable of flooding the world with accurately timed photographic shutters could do as well with artillery fuzes. Later, when fuzes came to be operated by radio echoes instead of clockwork, what was more natural than that we make that kind?

If you have some business to discuss about rugged and sophisticated electronics, get in touch with Eastman Kodak Company, Apparatus and Optical Division, Rochester 4, N. Y.

Flatness

Complexity, complexity! Rest the mind on a simple product, a photographic-emulsion-bearing rectangle 5.0 millimeters thick, 190 millimeters wide, 215 millimeters long, and flat within 0.00002-inch per inch. We mean: **Nowhere on the surface bearing the emulsion will it be possible to draw a circle of one-inch diameter containing a point of the surface more than 0.00002-inch distant from the plane of the circle.** Though achievement of such flatness is not simple, that is none of the user's business.

The user's business is to know the path of a man-made object moving across the sky and to know it with the best precision that man can currently master for the task. The work requires dimensional constancy of the material which bears the image.

That material is glass, a substance known to the Phoenicians and since improved. Our kind alters its linear dimensions by 0.00045% for each degree Fahrenheit of temperature change. Polyester, the most dimensionally stable of commercially available plastics, is called "stabilized" when its temperature coefficient is brought down to twice that. For the hardened steel from which gage blocks are made, the linear expansion coefficient is down to 0.00056%. Steel is opaque and does wicked things to sensitive emulsions.

George Eastman quit his job as a bank clerk in 1881 when he found he could coat emulsion on glass and sell it. That's how our whole business started. Don't think of the photographic plate as an antique, however. To find out how wrong that would be, try putting a question to Eastman Kodak Company, Special Sensitized Products Division, Rochester 4, N. Y. For one thing, you could ask about those ballistic camera plates announced above.

Kodak
TRADE MARK

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

ARS news

San Diego Spectacular June 8–12

26-Session Program Includes Biggest Roundup of Spaceflight Papers and Panelists Ever Assembled in United States

By James J. Harford, ARS Executive Secretary

As John E. Naugle, General Chairman of the 1959 ARS Semi-Annual Meeting, puts it in the printed program:

> "The vast and varied array of scientific and engineering talent in the membership of the AMERICAN ROCKET SOCIETY reflects the tremendous organization required to make even a simple measurement in space."

More than 100 purveyors of some of this talent will be presenting papers and participating in panels at the meeting to be held in the El Cortez Hotel, San Diego, June 8–12, 1959. Four of the 26 sessions are classified and will be sponsored by the Air Force Ballistic Missile Center. Evening sessions are being introduced for the first time in ARS programs with an IGY Report and, in another new wrinkle, a session devoted to the latest events in spaceflight (which should provide an opportunity to chew over such things as the space probe firings scheduled for the week before and during the meeting).

The luncheon speaker lineup includes ARS President Stapp, Convair's J. R. Dempsey, NASA's Abe Silverstein, and Vandenberg AFB's Maj. Gen. David Wade.

After a Tuesday evening, June 9, reception, sponsored by ARS Corporate Members Convair, Rohr Aircraft, Ryan Aeronautical, and Solar Aircraft, a banquet audience will hear Edward Teller, director of the Lawrence Radiation Laboratory, talk on "What Will We Find in Space?"

Sessions extend from Monday through Thursday. On Friday, June 12, field trips offer the enticing choice of witnessing a Polaris underwater jury rig firing, visiting a missile ship in San Diego Harbor, or touring the Convair-Astronautics plant, assembly line, and Sycamore static test site.

A very impressive ladies' program has been organized, including luncheons, fashion shows, boat trips, a tour of Mexico, a theatre trip, and a San Diego Zoo exploration.

Some 57 companies will spread over some 7460 sq ft of exhibits in a spacious exhibit hall across the street from the El Cortez Hotel on Tuesday, Wednesday, and Thursday.

Again quoting Chairman Naugle: "All of this in a San Diego setting which is, pardon our bias, inimitable from the standpoint of climate. Register early for meeting, hotel, and field trips. Bring your wife, by all means. We enthusiastically wait to welcome you." The complete program follows:

Monday, June 8

ASTRONOMY FROM A SPACE PLATFORM

9:30 a.m. **Cotillion Room**

Chairman: Fred L. Whipple, Smithsonian Astrophysical Observatory, Cambridge, Mass.

Vice-Chairman: William C. Erickson, Convair Scientific Research Laboratory, San Diego, Calif.

✦An Orbiting Astronomical Observing Platform, James E. Kupperian Jr., National Aeronautics and Space Administration, Washington, D.C. (793-59)

✦Radio Astronomy from Space, Fred T. Haddock, Univ. of Michigan, Ann Arbor, Mich. (794-59)

✦A Solar Observatory in Space, William A. Rense, Univ. of Colorado, Boulder, Colo. (795-59)

✦Orbiting Optical Telescopes, Robert J. Davis, Smithsonian Astrophysical Observatory, Cambridge, Mass. (796-59)

MAN TO SPACE

9:30 a.m. **Don Room**

Chairman: Capt. Julian E. Ward, Air Force Ballistic Missile Div., Inglewood, Calif.

Vice-Chairman: J. Gordon Wells, Northrop Corp., Hawthorne, Calif.

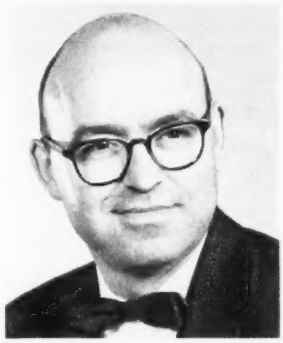
✦Epidemiological Considerations in Space Crew Holding Facility Design, Fratis L. Duff and Thomas A. Collins, School of Aviation Medicine, Gunter AFB, Ala. (797-59)

✦Role of Simulators in a Holding Facility, Gordon Eckstrand and Marty R. Rockway, Wright Air Development Center, Wright Patterson AFB, Ohio (798-59)

✦The Flight Surgeon's Role in Prelaunch Activities, Toby Freedman, North American Aviation, Inc., El Segundo, Calif. (799-59)

At left, the El Cortez Hotel, San Diego, where the meeting will be held. At right, the meeting committee at work. Clockwise, starting at lower left, are John E. Naugle, meeting chairman; R. D. Linnell; J. J. Mulvey; J. D. Clothier; S. Kaye; P. N. Sager; and P. O'Leary.

MEETING CHAIRMAN



John E. Naugle

BANQUET SPEAKER

Edward Teller

✦Psychologic Problems of Selection, Holding, and Care of Space Fliers, Siegfried J. Gerathewohl, Army Ordnance Missile Command, Redstone Arsenal, Ala. (800–59)

✦The Role of Physiologist in the Space Crew Holding Facility, Bruce W. Pincz, Air Force Ballistic Missile Division, Inglewood, Calif. (801-59)

LOGISTICS AND OPERATIONS

9:30 a.m. **Ballroom**

Chairman: Kurt H. Debus, Army Ballistic Missile Agency, Redstone Arsenal, Ala.
Vice-Chairman: Robert B. Rypinski, Chrysler Corp., Detroit, Mich.

All papers will be contained in a single preprint numbered (802–59)

✦Range Development in Anticipation of Rocket Systems, Maj. Gen. Donald N. Yates, Air Force Missile Test Center, Patrick AFB, Fla.

✦Evolution of Range Safety Philosophy Toward Over-Flying Inhabited Areas, Herbert L. Karsch, Allison Div., General Motors Corp., Indianapolis, Ind.

✦Design, Development, Testing, and Operational Use as a Continuum Rather than Discrete Activities, Maj. Gen. John B. Medaris, Army Ordnance Missile Command, Redstone Arsenal, Ala.

✦Training for Rocket System Testing, Production, Use, and Support, Capt. Robert F. Sellars, Naval Ordnance Test Unit, Patrick AFB, Fla.

✦Logistic Support of Low Density Rocket Systems, Robert B. Rypinski, Chrysler Corp., Detroit, Mich.

✦Logistics and Operations of Future Rocket Systems, C. J. Hamlin Jr., North American Aviation, Inc., Los Angeles, Calif.

LUNCHEON

12:30 p.m. **Cotillion Room**

Toastmaster: William F. Radcliffe, President, ARS San Diego Section.
Speaker: Col. John P. Stapp, President, American Rocket Society.
Subject: "Man's Mission in Space."

MAN IN NEAR SPACE

2:30 p.m. **Ballroom**

Co-Chairmen: Max Faget, National Aeronautics and Space Administration, Langley Field, Va. and Richard W. Lawton, Missile and Space Vehicles Dept., General Electric Co., Philadelphia, Pa.
Introductory Remarks: Max Faget, National Aeronautics and Space Administration, Langley Field, Va.

✦The Launching of a Manned Missile, Joachim Kuetter, Army Ballistic Missile Agency, Redstone Arsenal, Ala. (803-59)

✦Human Acceleration Effects for Rocket Flight, Capt. Neville Clark, Wright Air Development Center, Wright-Patterson AFB, Ohio. (804-59)

✦Protection Against Acceleration by Water Immersion, Cmdr. Martin G. Webb Jr. and R. Flanagan Gray, Naval Air Development Center, Johnsville, Pa. (805–59)

✦Pressure Suit Requirements for Space Vehicles, Edwin G. Vail, Wright Air Development Center, Wright-Patterson AFB, Ohio. (806-59)

✦Closed-Loop Centrifuge Simulation of Space Vehicle Performance, Randall M. Chambers and Harold V. Doertel, Aviation Medical Acceleration Laboratory, Naval Air Development Center, Johnsville, Pa. (807-59).

✦Problems in Visual Search for Space Vehicles, Myron Fischl, Missile and Space Vehicles Dept., General Electric Co., Philadelphia, Pa. (808-59)

SOUNDING ROCKETS

2:30 p.m. **Don Room**

Chairman: John W. Townsend Jr., National Aeronautics and Space Administration, Washington, D.C.
Vice-Chairman: R. W. Lowen, Convair Scientific Research Laboratory, San Diego, Calif.

✦Progress Report on Arcas, Cmdr. Willard S. Houston, Jr., Office of Naval Research, Washington, D.C. (809-59)

✦Nike-Asp Sounding Rocket, R. Bruce Cox, Cooper Development Corp., Monrovia, Calif. (810-59)

✦Argo Vertical Probes, E. G. Crofut, Aerolab Development Co., Pasadena, Calif. (811-59)

✦The Deployment and Inflation of Parachutes at Very High Altitudes, Robert L. Ammons, New Mexico State Univ., State College, N.M. (812-59)

✦Design Criteria for Upper Atmosphere Sounding Vehicles, Paul E. Prout, John T. Mosich, and Charles E. Roth Jr., Aerojet-General Corp., Azusa, Calif. (813-59)

GROUND SUPPORT

2:30 p.m. **Cotillion Room**

Chairman: Bernhardt L. Dorman, Aerojet-General Corporation, Azusa, Calif.
Vice-Chairman: Richard A. Schmidt, Air Force Flight Test Center, Edwards AFB, Calif.

✦Space Age Lighting, J. D. Ryan, Chrysler Corp., Detroit, Mich. (814-59)

✦Large Scale Systems for Servicing Cryogenic Fluids, Richard B. Hinckley and Robert E. Kendall, Arthur D. Little, Inc., Cambridge, Mass. (815-59)

✦Evolution of a Shock Suspension System for Hard Base Installation, Richard Koster, L. M. DeKanski, and Martin Kalb, American Machine and Foundry Co., Greenwich, Conn. (816-59)

✦Methods for Quantitatively Describing Rocket Engine Research and Development Operations, Jack M. Zimmerman and H. Kaspar, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif. (817-59)

THE IGY FINDINGS AND WHAT THEY MAY MEAN TO THE ASTRONAUT

(Panel)

8:00 p.m. **Ballroom**

Chairman: Joseph Kaplan, Univ. of California, Los Angeles, Calif.
Vice-Chairman: James I. Vette, Convair Scientific Research Lab, San Diego, Calif.

✦Solar Radiation, Herbert Friedman, Naval Research Laboratory, Washington, D.C.

✦Atmospheric Parameters, Herman E. La Gow, Naval Research Laboratory, Washington, D.C.

✦Charged Particle Radiation in Space, Ernest C. Ray and Carl E. McIlwain, State Univ. of Iowa, Iowa City, Iowa.

✦The Ionosphere, Warren Berning, Ballistic Research Laboratories, Aberdeen Proving Ground, Md.

Tuesday, June 9

PROGRESS REPORT ON PROBES

(Secret)

9:30 a.m. **Ballroom**

Chairman: Howard S. Seifert, Space Technology Laboratories, Los Angeles, Calif.
Vice-Chairman: N. W. O'Rourke, Convair-Astronautics, San Diego, Calif.

✦Objectives of Space Probes, John W. Town-

LUNCHEON SPEAKERS

Col. John P. Stapp

James R. Dempsey

Abe Silverstein

Maj. Gen. David Wade

send Jr., Beltsville Space Science Center, National Aeronautics and Space Administration, Beltsville, Md.

✦Army Participation in the National Satellite and Space Probe Program, Ernst Stuhlinger, Army Ballistic Missile Agency, Redstone Arsenal, Ala.

✦Progress Report on Project Able, Adolf K. Thiel, Space Technology Laboratories, Los Angeles, Calif.

✦Vehicle Capabilities, the Basis for Space Probes, Richard Canright, Advanced Research Projects Agency, Washington, D.C.

MISSILES AND SOCIETY

9:30 a.m. **Don Room**

Chairman: Frank Simpson III, Sheppard Mullin, Richter, Balthis & Hampton, Los Angeles, Calif.

Vice Chairman: W. J. Guedtner Jr., Convair Scientific Research Laboratory, San Diego, Calif.

✦The Economic Impact of Space Technology on Society, Gabriel M. Giannini, Giannini Plasmadyne Corp., Santa Ana, Calif. (818-59)

✦Mt. Everest to Mars—Man's Motivation, Ben L. Ettelson, Spacelabs, Inc., Tarzana, Calif. (819-59)

(Additional Papers to be announced.)

BURNING PROCESSES IN HIGH OUTPUT COMBUSTORS

9:30 a.m. **Cotillion Room**

Chairman: Martin Summerfield, Princeton Univ., Princeton, N.J.

Vice Chairman: Abe Berlad, Convair-Astronautics, San Diego, Calif.

✦An Estimate of Chemical Space Heating Rates in Gas-Phase Combustion with Application to Rocket Propellants, David A. Bittker and Richard S. Brokaw, National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

✦On Combustion in Bipropellant Rocket Chambers Based on Vaporization as the Rate-Limiting Process, Ernest Mayer, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif. (825-59)

✦Combustion Intensity in a Heterogeneous Stirred Reactor, Welby G. Courtney, Experiment, Inc., Richmond, Va. (826-59)

✦A Theory of Liquid Propellant Rocket Combustion Instability and Its Experimental Verification, Luigi Crocco, Jerry Grey, and David T. Harrje, Princeton Univ., Princeton, N.J. (827-59)

✦A Direct Method for Predicting Combustion Properties: Part 1, Laminar Velocities, J. R. Perrin, Marquardt Aircraft Co., Van Nuys, Calif.; Part 2, Flame Temperatures of Rocket Propellants and Ramjet Fuels, J. R. Perrin, C. J. O'Brien, and A. J. Kuestner, Marquardt Aircraft Co., Van Nuys, Calif. (828-59)

✦On the Relation of Droplet Consumption Rates to Liquid Strand Burning Rates, G. Alvin Mead II, Air Reduction Co., Murray Hill, N.J. (829-59)

12:30 p.m. **Cotillion Room**

LUNCHEON

Toastmaster: Ludwig Roth, Vice-President, ARS San Diego Section.

Speaker: Maj. Gen. David Wade, Commander, 1st Missile Division (SAC) Vandenberg AFB, Calif.

Subject: "Preparing for the Improbable."

HIGH PERFORMANCE PROPELLANTS

(Confidential)

2:30 p.m. **Ballroom**

Chairman: Charles H. King Jr., Pratt & Whitney Div., United Aircraft Corp., E. Hartford, Conn.

Vice-Chairman: Howard F. Dunholter, Convair-Astronautics, San Diego, Calif.

✦Low Pressure Combustion Experiment, James A. Bottorff, Aerojet-General Corp., Azusa, Calif.

✦Performance Characteristics of High Energy Propellants Utilizing Liquid Fluorine, James R. Flanagan and Frank W. Stephenson Jr., Bell Aircraft Corp., Buffalo, N.Y.

✦High Energy Storable Propellants, Jacob Silverman, Rocketdyne, Canoga Park, Calif.

MICROMINIATURIZATION

2:30 p.m. **Don Room**

Chairman: John E. Witherspoon, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif.

Vice-Chairman: J. H. Hauser, Convair-Astronautics, San Diego, Calif.

✦Microminiaturization for Space Applications, Donal B. Duncan, Autonetics Div., North American Aviation, Inc., Downey, Calif. (830-59)

✦An Interim Approach to Microminiaturization of 5 and 10 Mega-bit Transistorized Logic, James H. Foster, Erie Resistor Corp., Erie, Pa. (831-59)

✦Data Gathering Mechanisms for Reliability Determination, Richard G. Schimpf, Elgin Micronics Div., Elgin National Watch Co., Elgin, Ill. (832-59)

✦Missile-Borne Magnetic Recorder, Mark M. Siera, Lockheed Missiles and Space Div., Palo Alto, Calif. (833-59)

THERMOSTRUCTURAL MATERIALS

2:30 p.m. **Cotillion Room**

Chairman: Wolfgang H. Steurer, Convair, San Diego, Calif.

Vice-Chairman: A. H. Schoen, Convair Scientific Research Laboratory, San Diego, Calif.

✦Thermal Problems of Satellites, Gerhard Heller, Army Ballistic Missile Agency, Redstone Arsenal, Ala. (834-59)

✦Implications of Thermal Protection Systems to Materials Development, William F. Harris and William S. Pellini, National Academy of Sciences, Washington, D.C. (835-59)

✦Materials for Re-Entry of Satellites, Leo Steg, Missile and Space Vehicles Dept., General Electric Co., Philadelphia, Pa. (836-59)

✦Fused Silica—A Material for Thermal Protection Systems, Jesse D. Walton Jr., Georgia Institute of Technology, Atlanta, Ga. (837-59)

✦The Large High Pressure Arc Plasma Generator: A Facility for Simulating Missile and Satellite Re-Entry, Peter H. Rose, William E. Powers, and Daniel Hritzay, Avco Research Laboratory, Everett, Mass. (838-59)

✦The Role of Emissivity in the Design of Space Vehicles, Leo S. Salzberg, Jules I. Wittebort, and Frank V. Zaleski, Wright Air Development Center, Wright-Patterson AFB, Ohio. (839-59)

6:00 p.m. **Cotillion Room**

RECEPTION

Sponsored by
Convair
Rohr Aircraft Corp.
Ryan Aeronautical Co.
Solar Aircraft Co.

7:00 p.m. **Grand Ballroom**

BANQUET

Toastmaster: Charles L. Critchfield, Director of Scientific Research, Convair, San Diego, Calif.

Speaker: Edward Teller, Director, Ernest Orlando Lawrence Radiation Laboratory, Livermore, Calif.

Subject: "What Will We Find in Space?"

ARS 1959 Paper Deadlines

Date	Meeting	Location	*Deadline
June 8–12	Semi-Annual Meeting	San Diego, Calif.	Past
July 20–21	Propellant Thermodynamics & Handling Conference	Ohio State Univ.	Past
Aug. 24–26	Gas Dynamics Symposium	Northwestern Univ.	June 22
Aug. 31–Sept. 5	10th IAF Congress	Westminster, London	May 15
Nov. 16–20	14th Annual Meeting	Washington, D.C.	Aug. 17
1960			
Jan. 28–29	Solid Propellants Conference	Princeton Univ.	Nov. 16

* For reviewed and approved manuscripts in the New York office. Subtract 30 days for unsolicited papers that must go through the reviewing procedure and 60 days for abstracts submitted for consideration. Send all papers and abstracts to Meetings Manager, ARS, 500 Fifth Ave., New York 36, N.Y.

...NEWS IS HAPPENING AT NORTHROP

Demonstrating the platform of LINS – new, Lightweight Inertial Navigation System – is Dr. William F. Ballhaus, Vice President and General Manager of Nortronics.

NORTRONICS REVEALS LINS... COMPLETE PRECISION INERTIAL NAVIGATION SYSTEM!

A recent demonstration at Nortronics' Guidance Symposium revealed the most advanced precision inertial guidance system ever assembled. LINS – Lightweight Inertial Navigation System – includes platform, platform electronics, environmental control and computer. Total system weight: slightly in excess of 100 pounds. Equipment volume: less than three cubic feet.

Actual working hardware, LINS is a complete, precision system for automatic navigation applications to advanced aircraft, drones, missiles, and space vehicles. It is ready now – the latest result of Nortronics' more than twelve years of creative research and production in the field of automatic guidance and navigation systems.

If you have the need to know more – contact Nortronics today, regarding LINS for your own system requirement. Nortronics' experience offers unique and proven capabilities in tailoring the design, development and production of complete and integrated guidance systems to your requirements.

NORTRONICS

HAWTHORNE, CALIFORNIA
A Division of Northrop Corporation

On the calendar

1959

June 1–3	3rd Annual Summer Conference on Vacuum Metallurgy, NYU College of Engineering, University Heights, Bronx, N.Y.
June 4–5	IRE National Conference of Professional Group on Production Techniques, Villa Hotel, Palo Alto, Calif.
June 8–11	**ARS Semi-Annual Meeting and Astronautical Exposition, San Diego, Calif.**
June 11–13	1959 Heat Transfer and Fluid Mechanics Institute, Univ. of Calif., Los Angeles.
June 13–23	UNESCO Int'l Conference on Information Processing, Paris.
June 16–17	Industry Missile and Space Conference of Michigan Aeronautics and Space Assn., Sheraton-Cadillac Hotel, Detroit, Mich.
June 16–18	National Meeting of American Meteorological Society, San Diego, Calif., in conjunction with Pacific Div., American Assn. for Advancement of Science.
June 17–18	Blood Flowmeters Symposium, Univ. of Nebraska College of Medicine, Omaha.
June 17–20	Annual Meeting of National Society of Professional Engineers, Commodore Hotel, New York, N.Y.
June 24–26	2nd National Symposium of ISA Nuclear Industry Division, Idaho Falls, Idaho.
July 20–21	**ARS Propellant Thermodynamics and Handling Conference, Ohio State Univ., Columbus, Ohio.**
July 24–26	AIEE Air Transportation Conference, in conjunction with 1959 Summer and Pacific General Meeting, Olympic Hotel, Seattle, Wash.
Aug. 9–12	ASME-AICE Heat Transfer Conference, Univ. of Connecticut, Storrs, Conn.
Aug. 18–21	1959 Western Electronic Show and Convention, San Francisco.
Aug. 24–26	**ARS Gas Dynamics Symposium, Dynamics of Conducting Fluids, Northwestern Univ., Evanston, Ill.**
Aug. 27–29	American Physical Society 1959 Summer Meeting in the West, Univ. of Hawaii, Honolulu.
Aug. 28–29	British Commonwealth Space Flight Symposium, Westminster, London.
Aug. 31–Sept. 2	4th Int'l Symposium on Free Radical Stabilization at National Bureau of Standards, Washington, D.C.
Aug. 31–Sept. 5	**10th Annual International Astronautical Federation Congress, Westminster, London.**
Sept. 2–4	1959 Cryogenic Engineering Conference, Univ. of California, Berkeley, Calif.
Sept. 9–11	Midwestern Conference on Fluid and Solid Mechanics, Univ. of Texas, Austin.
Sept. 22–24	Industrial Nuclear Technology Conference, co-sponsored by Illinois Inst. of Tech., at Morrison Hotel, Chicago.
Sept. 28–Oct. 1	American Welding Society fall meeting, Sheraton-Cadillac Hotel, Detroit, Mich.
Oct. 6–9	Int'l Symposium on High Temperature Technology, sponsored by Stanford Research Institute, at Asilomar, Calif.
Oct. 7–9	ASME-AIME Solid Fuels Conference, Cincinnati, Ohio.
Oct. 7–9	6th National Symposium on Vacuum Technology, American Vacuum Society, Sheraton Hotel, Philadelphia.
Oct. 12–14	National Electronics Conference, co-sponsored by Illinois Inst. of Tech., at Hotel Sherman, Chicago.
Oct. 26–28	IRE Professional Group East Coast Conference on Aeronautical and Navigational Electronics, Lord Baltimore Hotel, Baltimore, Md.
Oct. 26–30	1959 National Conference of the Society of Photographic Scientists and Engineers, Edgewater Beach Hotel, Chicago.
Oct. 28–29	6th Annual Computer Applications Symposium, sponsored by Illinois Inst. of Tech., at Morrison Hotel, Chicago.
Nov. 16–20	**ARS 14th Annual Meeting and Astronautical Exposition, Washington, D.C.**
Nov. 16–20	5th Int'l Automation Exposition and Congress, N.Y. Trade Show Bldg., New York, N.Y.

1960

Jan. 28–29	**ARS Solid Propellants Conference, Princeton Univ., Princeton, N.J.**
Aug. 31–Sept. 7	10th Int'l Congress of Applied Mechanics, Congress Bldg., Stresa, Italy.

Wednesday, June 10

GUIDANCE SYSTEMS

(Secret)

9:30 a.m. **Ballroom**

Chairman: Robert J. Parks, Jet Propulsion Laboratory, Pasadena, Calif.
Vice-Chairman: J. W. Crooks, Convair Astronautics, San Diego, Calif.

✦Gimbal-less Inertial Systems, Azriel Rosenfeld, Ford Instrument Co., Long Island City, N.Y.

✦Interplanetary Guidance, A. R. Maxwell Noton, Jet Propulsion Laboratory, Pasadena, Calif.

✦The Polaris Inertial Guidance Digital Computer, Eldon C. Hall, MIT Instrumentation Laboratory, Cambridge, Mass.

✦Inertial Measurements with High Acceleration Inputs, George A. Harter, Space Technology Labs, Los Angeles, Calif.

✦Radio Guidance of Satellite Vehicles into Orbit, Earle B. Mullen, General Electric Co., Syracuse, N.Y.

SPACE COMMUNICATIONS

9:30 a.m. **Don Room**

Chairman: Frank W. Lehan, Space Electronics Corp., Glendale, Calif.
Vice-Chairman: Fred Casal, Convair Scientific Research Lab., San Diego, Calif.

✦Peltier Cooling of Electrical Components in Telemetering Packages, Raymond Marlow, Texas Instruments, Inc., Dallas, Tex. (841-59)

✦A Novel Data Transmission System for Impedance Transducers, Olin B. King, Army Ballistic Missile Agency, Huntsville, Ala. (842-59)

✦A New Telemetry System Using Efficient Communication Techniques, A. W. Newberry, Space Electronics Corp., Glendale, Calif. (843-59)

✦Satellite Instrumentation Component Design, Donald G. Lammers and Peter M. Smith, Applied Science Corp. of Princeton, Princeton, N.J. (844-59)

NUCLEAR PROPULSION

9:30 a.m. **Cotillion Room**

Chairman: Frank Rom, National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
Vice-Chairman: Warren H. Thiel, Convair, San Diego, Calif.

✦Comparison of Some Advanced Nuclear Propulsion Systems, Edward F. Wahl, National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. (846-59)

✦Advanced Propulsion Concepts, Edward Fisher, Lockheed Missiles and Space Div., Palo Alto, Calif. (847-59)

✦A Gaseous-Core Nuclear Rocket Utilizing Hydrodynamic Containment of Fissionable Material, Jerry Grey, Princeton Univ., Princeton, N.J. (848-59)

✦Radiation Problems in the Rover Program, Glen A. Graves, Los Alamos Scientific Lab, Los Alamos, N.M. (849-59)

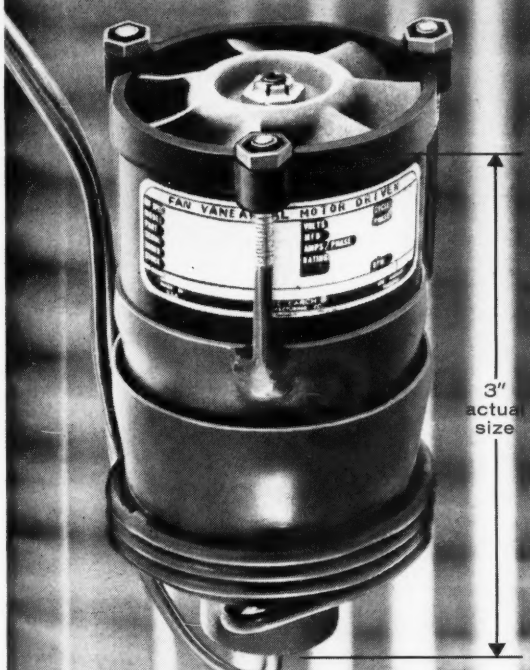
✦Measurements of Heat Transfer and Friction Coefficients for Helium Flowing in a Tube at Surface Temperatures up to 5900° R, Maynard F. Taylor and Thomas A. Kirchgessner, National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. (850-59)

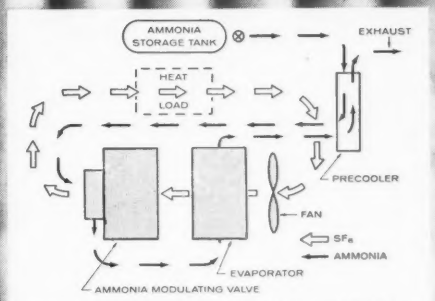
12:30 p.m **Cotillion Room**

LUNCHEON

Toastmaster: William H. Dorrance, Assistant to the Director of Scientific Re-

LIGHTWEIGHT airborne electronic cooling package





PERFORMANCE CHARACTERISTICS—
Heat Rejection: 200 watts... Inlet Gas Temperature to Component Housing: 130°F.... Weight of Fan, Evaporator and Controls: 1.25 lb.

Spans the gap between direct ambient cooling and closed cycle systems

• *This AiResearch open-cycle cooling unit* is designed for environmental conditioning of electronic and electromechanical equipment in problems of low total heat dissipation aboard aircraft and missiles.

Much lighter and less complex in operation than closed cycle systems, this compact package is recommended when required total heat dissipation is low... large heat loads for short periods of time, or small heat loads for long periods of time. It also replaces direct ambient cooling systems when ambient sink is not low enough or not easily available.

Ammonia in this expendable evaporative system cools sulfur hexafluoride (SF_6) which passes over the hot electronic components. The SF_6 then recirculates for cooling, and the ammonia is dumped overboard.

Applications of this system include: inertial guidance system cooling, missile transient cooling, and spot cooling where ambient sink is not available.

AiResearch has designed and manufactured cooling systems of all types ... direct ambient, closed and open-cycle systems handling all magnitudes of cooling loads and utilizing various working fluids. We invite you to send us details of your problem.

THE GARRETT CORPORATION
AiResearch Manufacturing Divisions
Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

American Rocket Society

500 Fifth Avenue, New York 36, N. Y.

Founded 1930

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Abe Zarem, Non-Propulsive Power

search, Convair, San Diego, Calif.

Speaker: J. R. Dempsey, Manager, Convair-Astronautics and Vice President, Convair, San Diego, Calif.

Subject: "Project Centaur—A Space Laboratory."

HIGH ENERGY LIQUID ROCKETS

(Confidential)

2:30 p.m. **Ballroom**

Chairman: A. O. Tischler, National Aeronautics and Space Administration, Washington, D.C.

Vice-Chairman: Richard Wentink, Convair-Astronautics, San Diego, Calif.

✦Nomad Series of High Performance Rocket Systems, Walter R. Studhalter, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif.

✦Lox and SF-1 Thrust Chamber Experiments, I. L. Odgers and W. J. Conner, Aerojet-General Corp., Sacramento, Calif.

✦Thrust Chamber Experiments with High Energy Propellants, John L. Sloop, National Aeronautics and Space Administration, Cleveland, Ohio.

✦Engine Component Compatibility and Performance with an Oxidizer Consisting of 20% (By Weight) Liquid Fluorine and 80% Liquid Oxygen, Gilbert C. Munroe, General Electric Co., Ballston Spa, N.Y.

HYPERSONICS

2:30 p.m. **Don Room**

Chairman: William H. Dorrance, Convair, San Diego, Calif.

Vice-Chairman: Richard Linnell, Convair, San Diego, Calif.

✦Experiments on the Departure from Chemical Equilibrium in a Supersonic Flow, Peter P. Wegener, Jet Propulsion Laboratory, Pasadena, Calif. (851-59)

✦Non-Equilibrium Flow in Gas Dynamics, Ting Yi Li, Rensselaer Polytechnic Institute, Troy, N. Y. (852-59)

✦Heat Diffusion Through Gases, Including Real Gas Effects Which Occur at the Stagnation Region of High Speed Vehicles, C. Frederick Hansen, Ames Research Center, National Aeronautics and Space Administration, Moffett Field, Calif. (853-59)

✦A Study of Ablation on Ice Models at M = 5.8, Toshi Kubota, California Institute of Technology, Pasadena, Calif. (854-59)

✦Shock Wave—Boundary Layer Interaction and Leading Edge Slip on a Flat Plate in Hypersonic Flow, H. T. Nagamatsu and R. E. Sheer Jr., General Eleteric Research Lab., Schenectady, N. Y. (855-59)

✦Experimental Investigation of Flat Plate Hypersonic Turbulent Boundary Layer with Heat Transfer, Eva M. Winkler, Naval Ordnance Lab, Silver Spring, Md. (856-59)

✦Mass Transfer in a Turbulent Boundary Layer, Bernard M. Leadon and E. Roy Bartle, Convair Scientific Research Lab., San Diego, Calif. (857-59)

✦Some Aerothermodynamic Considerations of Hypervelocity Vehicles, Arthur E. Flathers, General Electric Co., Philadelphia, Pa. (858-59)

TELEMETERING

2:30 p.m. **Cotillion Room**

Chairman: Myron G. Pawley, U.S. Naval Ordnance Lab., Corona, Calif.

Vice-Chairman: George C. Tweed, Convair-Astronautics, San Diego, Calif.

✦Simplification of Environmental Measurements, Merl R. Beckman, U.S. Naval Missile Test Center, Point Mugu, Calif. (859-59)

✦A Practical Approach to PCM Telemetry in Missiles, P. Robert Palmer, Sandia Corp., Sandia Base, Albuquerque, N.M. (860-59)

✦A Miniature Carrier Amplifier System for Use with Strain Gauges, Earl Grant, Statham Instruments, Inc., Los Angeles, Calif. (862-59)

✦The New Eglin-Gulf Test Range Instrumentation System, A. H. Lang, ITT Labs, Nutley, N.J. and G. L. Dunn, Applied Science Corp. of Princeton, Princeton, N.J. (863-59)

LATEST EVENTS IN SPACE FLIGHT

8:00 p.m. **Ballroom**

Chairman: Krafft Ehricke, Convair-Astronautics, San Diego, Calif.

Vice-Chairman: F. D'Vincent, Convair-Astronautics, San Diego, Calif.

This session will be devoted to up-to-the-minute presentations on current space vehicle and satellite launchings.

Thursday, June 11

AUXILIARY POWER SOURCES

9:30 a.m. **Don Room**

Chairman: John Huth, The Rand Corp., Santa Monica, Calif.

Vice-Chairman: Erwin O. A. Naumann, Solar Aircraft Co., San Diego, Calif.

✦Space Probe Power Systems, Selection and Development, R. C. Hamilton, Jet Propulsion Lab, Pasadena, Calif. (864-59)

✦Solar Power Converter Systems for Space Application, W. W. Jacquish, Hoffman Labs, Los Angeles, Calif. (865-59)

✦Electrochemical Energy Sources for Space Flight Applications, M. Eisenberg, Lockheed Missiles and Space Div., Sunnyvale, Calif. (866-59)

✦Space Vehicle Power Systems, Eugene B. Zwick, Sundstrand Turbo Div., Pacoima, Calif. (867-59)

BALLISTICS OF SPACE VEHICLES

9:30 a.m. **Ballroom**

Chairman: Samuel Herrick, Univ. of California, Los Angeles, Calif.

Vice-Chairman: W. H. Schwidetsky, Convair-Astronautics, San Diego, Calif.

✦An Analytic Determination ot the Maximum Range of a Ballistic Missile from Launch to Target, Alfred A. Adler, Bell Aircraft Corp., Snyder, N. Y. (868-59)

✦Efficient Precision Orbit Computation Techniques, Robert M. L. Baker, Jr., George B. Westrom, Charles G. Hilton, Jeannine L. Arsenault, Robert H. Gersten, and Elsie Browne, Aeronutronic Systems, Inc., Glendale, Calif. (869-59)

✦Interplanetary Ballistic Orbits, Hans K. Karrenberg and Paul D. Arthur, Systems Corp. of America, Los Angeles, Calif. (870-59)

✦Semi-Analytical Calculations of Orbital Perturbations of Earth Satellites, Y. Kozai, Smithsonian Astrophysical Observatory, Cambridge, Mass. (871-59)

✦Takeoff from a Satellite Orbit, Jack Lorell

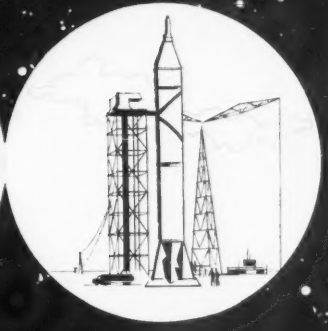
At the

TAPCO GROUP...

THE PEOPLE

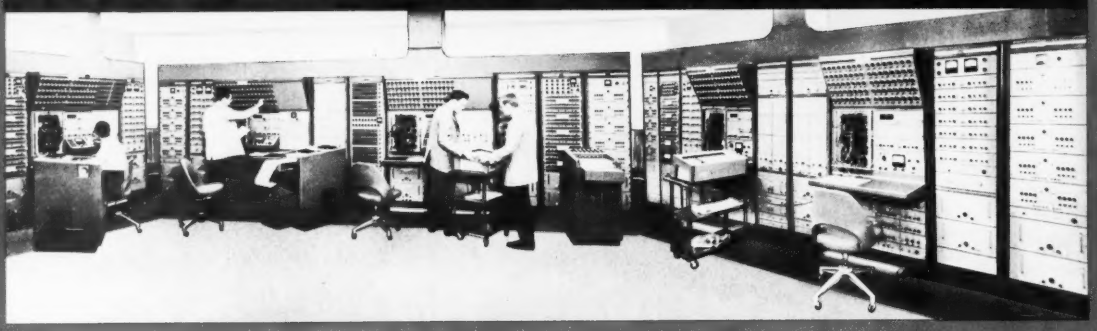
THE FACILITIES

THE KNOW-HOW



to design and make systems, subsystems, and components

This 80-channel, 240-circuit analog computer in the TAPCO Group is able to speed the engineering of complex devices, can also simulate multiple-variant operating conditions for control systems.

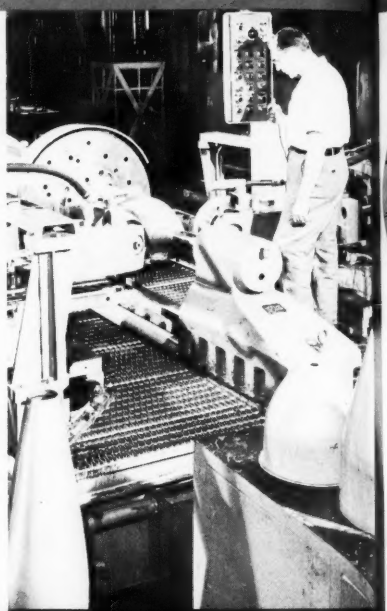


AT TAPCO . . . 10,000 people combine every talent needed to create systems, subsystems, hardware

People at TAPCO . . . over 10,000 of them . . . are fully competent in the design and production of unusual rotating machines to handle fluids, electricity, and high-temperature gases. They have broad experience with unusual parts and structures requiring special resistance to shock, temperature, and corrosion . . . can produce components of all types in space-age metals and unusual alloys of common metals.

Development of unusual alloys and ways to fabricate them are nothing new to TAPCO people. More than 55 years of experience on metallurgical developments, fabrication and heat-treating methods, and unusual welding are available in the TAPCO Group.

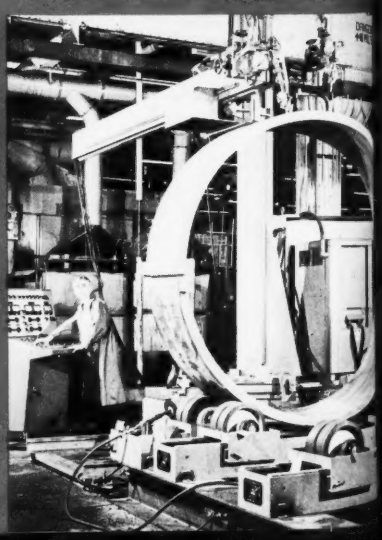
Over one-third of the TAPCO Group people are engineers, with degrees covering every industrial science. They can quickly translate your idea for a vehicle, ground support unit, or system into a practical system, subsystem, or component.

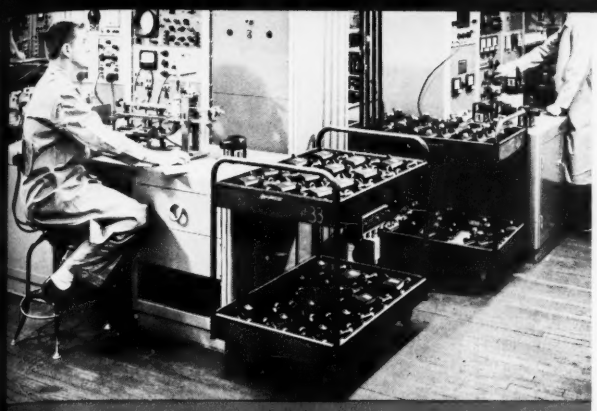


"Chipless machining" of special-alloy nose cones for Bullpup air-to-surface missiles by hydrospinning, or roll-forming, at a high production rate in the TAPCO Group facilities

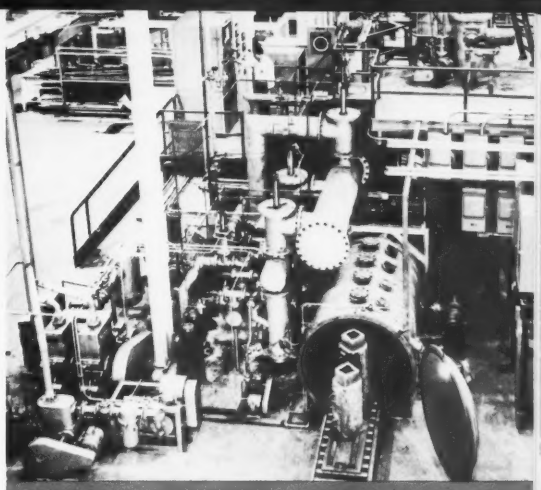
Complete facilities and manpower are available in the TAPCO Group for simulation, certification and predelivery testing of equipment built by TAPCO.

Positioning heavy stainless steel ring for submerged arc welding operation on a Herrick 10 x 12-foot automatic welder. One of many precision welding machines at the TAPCO plant.





Production testing of microwave components at the electronics facility of the TAPCO Group.



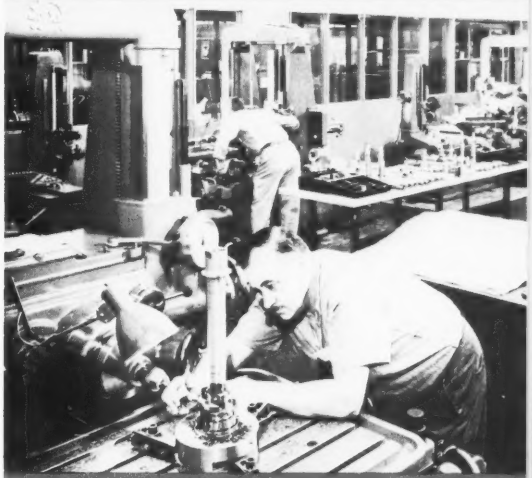
Vacuum-cast super-alloy ingots and precision investment castings are produced with facilities that include one of the largest induction vacuum furnaces—a 2,400-pound unit equipped for continuous charging, melting and pouring while maintaining evacuated atmospheres of 10 microns or less.

Facilities at TAPCO to turn unusual ideas into systems, subsystems, components

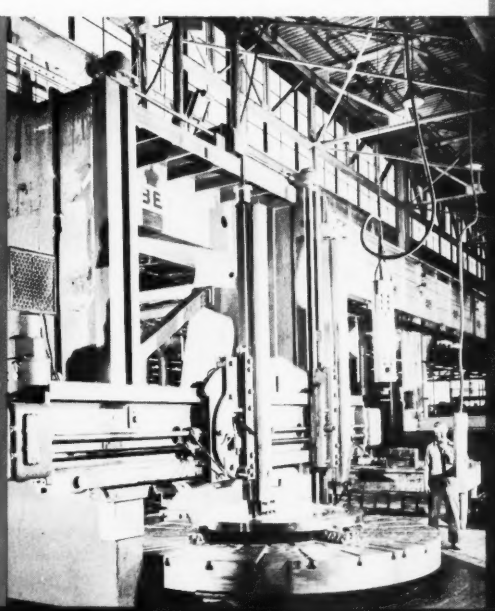
From conception to final delivery, TAPCO facilities provide for all phases of design, prototype, manufacture, and testing of a complete system, a subsystem, or major components of a system.

Research and development facilities within the TAPCO Group can process and interpret data for any problem, can simulate multi-variable conditions to govern test runs, can help reduce lead-time between original concept and final delivery.

The 11 plants within the TAPCO Group have 3,000,000 square feet of engineering and manufacturing area, half of it under one roof. Research and development equipment, production machinery and other facilities are valued at $150,000,000.



Optical jig mills in controlled atmosphere rooms at TAPCO are available for high-precision machining, as well as for the accurate inspection of dimensions and contours.



Newly installed at TAPCO, for machining large jet and missile engine cases and nuclear reactor structurals, this Betts boring mill can do highly precise, high-production turning, boring, and facing of pieces up to 144 inches in diameter, 120 inches in length.

TRW

TAPCO GROUP

Thompson Ramo Wooldridge Inc.

CLEVELAND 17, OHIO

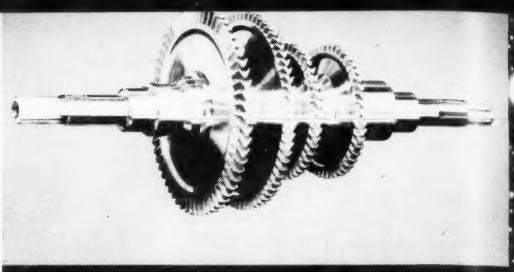
DESIGNERS AND MANUFACTURERS OF SYSTEMS, SUBSYSTEMS AND COMPONENTS FOR THE AIRCRAFT, MISSILE, ORDNANCE, ELECTRONIC, AND NUCLEAR INDUSTRIES

AT TAPCO, experience, ingenuity, creativity to solve your problems, develop your ideas

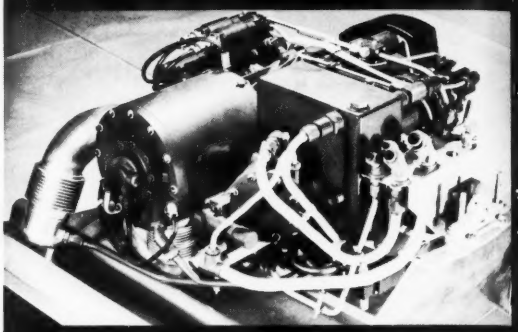
The TAPCO Group has a broad experience with the behavior of all types of fuels under all conditions, from ground level to highest altitudes. This experience has contributed to the design and production of over 1,100,000 aircraft and missile fuel pumps of all types.

Experience in the TAPCO Group also includes nuclear-reactor engineering, production of high-speed rotating machines to meet all temperature problems, and development and production of self-contained auxiliary power units of various sizes, duty-requirements, and configurations.

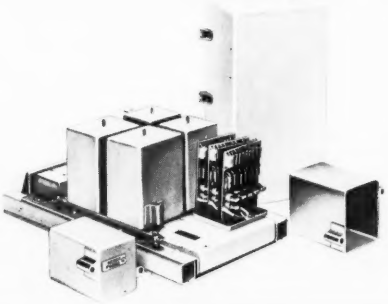
Let a TAPCO Group sales engineer explain how we can work with you to develop and deliver on-schedule any program or part of a program to meet your specifications.



Precision one-piece, four-stage turbine rotor for high-speed operation in auxiliary power units. Designed and manufactured at TAPCO.



APU developed and built by the TAPCO Group for use with exotic fuels. Testing was done under simulated operating conditions at TAPCO's 1100-acre Roanoke Test Facility.



Electronics equipment produced by the TAPCO Group includes wave guide switches, speed-sensing devices, microwave antennas and filters, computing systems, electro-pneumatic controls.

The TAPCO Group designed and supplied the entire roof structure, forward and aft doors, and actuating system for the Bomarc Model II missile shelters at the first operational sites at Eglin and Suffolk County Air Force bases. TAPCO also provided full field supervision to direct assembly and demonstrate functional operation.

TRW

TAPCO GROU

Thompson Ramo Wooldridge Inc.

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DESIGNERS AND MANUFACTURERS OF SYSTEMS, SUBSYST
AND COMPONENTS FOR THE AIRCRAFT, MISSILE, ORDNA
ELECTRONIC, AND NUCLEAR INDUSTRIES

and Harry Lass, Jet Propulsion Lab., Pasadena, Calif. (872-59)

✦Selected Topics in Astro-Geodesy, John A. O'Keefe, National Aeronautics and Space Administration, Washington, D.C. (873-59)

✦Reliability of Interplanetary and Lunar Orbit Computations, V. G. Szebehely, General Electric Co., Philadelphia, Pa. (874-59)

RAMJETS

9:30 a.m. **Cotillion Room**

Chairman: Ed Chapman, Convair, San Diego, Calif.

Vice-Chairman: George B. Nicoloff, Convair, San Diego, Calif.

✦A Survey of Hypersonic Ramjet Concepts, Richard J. Weber, National Aeronautics and Space Administration, Cleveland, Ohio. (875-59)

✦The Solid Propellant Ducted Rocket Propulsion System, Joseph W. Wiggins, Thiokol Chemical Corp., Redstone Arsenal, Ala. (876-59)

✦High Energy Ramjet Fuels, G. F. Huff and W. R. Millard, Callery Chemical Co., Callery, Pa. (877-59)

✦A Minimum Weight Design Study of Ramjet Powered Long Range Hypersonic Cruise Vehicles, J. R. Campbell and R. A. Needham, Marquardt Aircraft Co., Van Nuys, Calif. (878-59).

12:30 p.m. **Cotillion Room**

LUNCHEON

Toastmaster: Curtis L. Bates, Assistant Chief Engineer, Ryan Aeronautical Co., San Diego, Calif.

Speaker: Abe Silverstein, Director of Space Flight Development, National Aeronautics and Space Administration, Washington, D.C.

ELECTRICAL PROPULSION

2:30 p.m. **Ballroom**

Chairman: David Langmuir, Ramo-Wooldridge Div., Thompson Ramo Wooldridge, Inc., Los Angeles, Calif.

Vice-Chairman: Dave Garber, Convair-Astronautics, San Diego, Calif.

✦Powered Trajectory Studies for Low Thrust Space Vehicles, Robert H. Fox, Univ. of California, Radiation Lab., Berkeley, Calif. (879-59)

✦Engineering and Scientific Problems of Ion Propulsion, Stanton L. Eilenberg and Albert L. C. Huebner, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif. (880-59)

✦A Survey of the Electrical Propulsion Systems, Y. C. Lee, Aerojet-General Corp., Azusa, Calif. (881-59)

✦Generation and Neutralization of Ions for Electrostatic Propulsion, H. Shelton, R. F. Wuerker, and J. M. Sellen, Ramo-Wooldridge Div., Thompson Ramo Wooldridge, Inc., Los Angeles, Calif. (882-59)

✦Ion Source for Ion Propulsion Systems, Sam Naiditch, Electro-Optical Systems, Inc., Pasadena, Calif. (883-59)

✦Decelerate Ionic Thrust Device, Robert N. Seitz and Manfred J. Raether, Army Ballistic Missile Agency, Redstone Arsenal, Ala. (884-59)

A Pierce Gun Design for an Accelerate-

SOLID ROCKET TECHNOLOGY

2:30 p.m. **Don Room**

Chairman: Ivan E. Tuhy, The Martin Co., Baltimore, Md.

Vice-Chairman: A. W. Armstrong, Convair, San Diego, Calif.

✦Thermodynamic Properties of Propellant Gas Systems Containing a Condensable Component, Denis J. Zigrang, The Martin Co., Denver, Colo. (885-59)

✦Solid Propellants as a Power Source, Melvin Cohen, The Hicks Corp., Washington D.C. and Lieut. Cmdr. Edward J. Sheehy, Bureau of Ordnance, U.S. Navy, Washington, D.C. (886-59).

✦Isolation of Data Inaccuracies Through Mass-Flow Analysis, Jack Ryan, Grand Central Rocket Co., Redlands, Calif. (887-59)

✦Stage Nozzle Optimization for a Multi-Stage Missile, William C. Stone, McDonnell Aircraft Corp., St. Louis, Mo. (888-59)

COMBUSTION TOPICS IN CURRICULA

(Panel)

2:30 p.m. **Cotillion Room**

Chairman: Capt. Carl A. Anderson, Air Force Institute of Technology, Wright-Patterson AFB, Ohio.

Chairman: W. F. Bradfield, Convair Scientific Research Lab, San Diego, Calif.

This session is under the joint sponsorship of ARS and the Aeronautical Division of the American Society for Engineering Education.

✦Probable Direction of Combustion Research, K. Scheller, Wright Air Development Center, Wright-Patterson AFB ,Ohio.

✦Industry's Need for Combustion-Trained Personnel, Robert S. Levine, Rocketdyne, Canoga Park, Calif.

✦Undergraduate Curricula, A. Cronk, Texas A. & M, College Station, Tex.

✦Graduate Curricula, Ali Bulent Cambel, Northwestern Univ., Evanston, Ill.

Friday, June 12

FIELD TRIPS

No. 1. **7:00 a.m.**

Polaris Underwater Jury Rig Firing

Group will leave the El Cortez Hotel by bus for the docks where it will board a high speed destroyer and be carried to San Clemente Island to witness the firing. The trip is subject to last minute cancellations due to operational requirements or bad weather. Scheduled for return by 6:00 p.m. Tour limited to 200 persons.

Bus fare: $1.00

No. 2 **7:00 a.m.**

MISSILE SHIP TRIP

Tour will leave the El Cortez Hotel in buses to the docks. The group will tour the ship and be given a demonstration of firing of missiles out at sea. This trip is also subject to last minute cancellations due to operational requirements or bad weather. The trip is scheduled for completion by 6:00 p.m. and will be limited to 200 persons.

Bus fare: $1.00

No. 3 **9:00, 10:00 & 11:00 a.m.**

Convair-Astronautics Tour

Three tours will depart by bus from the El Cortez Hotel an hour apart, starting at 9:00 a.m. for a tour of the plant. The tours will each last about four hours and will be limited to 40 persons.

Bus fare: $1.50

Other Trips Available

Arrangements can be made at the Registration Desk for the following trips:

Convair, San Diego—F-106 and 880 facilities.

Rohr Aircraft—Special structural materials, sound suppressors, and thrust reversers.

Ryan Aeronautical—DC-8 pods and pylons, KC-135 aft fuselage, Corporal missile rocket engines, fabrication of alloys.

Solar Aircraft—Special Structural Materials.

Ladies Program

All Departures from Pool Entrance, El Cortez Hotel.

Monday, June 8

10:30 a.m.

Orientation

Gather at El Cortez Pool near Ladies' Convention Headquarters, Room 105. Hostesses will welcome you, explain the program, suggest other activities, and answer your questions.

Tour A (Ladies Only) **11:30 a.m.**

Bali Hai Luncheon and Tour

Buffet luncheon at Bali Hai Restaurant followed by a tour of San Diego—Old San Diego, Balboa Park, Point Loma's Old Spanish Lighthouse, Mission Bay Aquatic Park, and the beaches and beautiful homes of La Jolla.

Luncheon, tour, tips, and tax: $6.00

Tour B **8:00 p.m.**

Capri Movie Tour

Visit the Capri, San Diego's outstanding one-feature movie to see "The Sleeping Beauty."

Transportation, tickets, and tax: $3.00

Tuesday, June 9

Tour C (Ladies Only) **9:30 a.m.**

San Diego Boat Trip and Fashion Show

Two-hour cruise of San Diego Bay, with closeup views of naval installations and ships, yacht harbor, and civic buildings. Buffet

ASTRO Covers Available

In response to a number of requests, ASTRONAUTICS is offering full-color reprints of its covers, beginning with the May 1959 issue. Reprints will be in the form of laminated plastic display plaques, with a metal D-ring on the back for easy mounting on a wall. The full-size cover, with a suitable mat, is mounted on $^1/_4$-in. rigid hardboard, with beveled edges, and over-laminated with transparent vinyl plastic. Size of the plaque is 11 by 12 in. Cost is $2.00, and only a limited supply of covers will be available each month.

The plaques may be obtained by writing to ASTRONAUTICS, 500 Fifth Ave., New York 36, N.Y.

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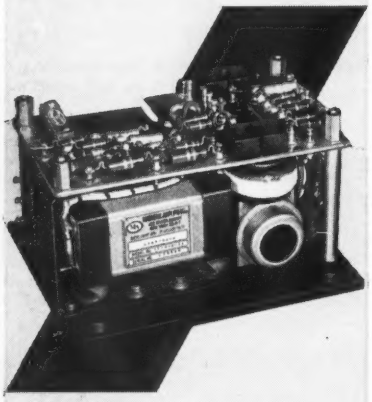

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luncheon at the Sky Room of the El Cortez for a bird's-eye view of the city. San Diego's own fiesta fashions and California sportswear will be featured at a fashion show by Marston's with dessert served in their tea room.

Cruise, luncheon, fashion show, tips, and tax $7.25

6:00 p.m.

Reception and banquet, Grand Ballroom, El Cortez.

Dinner, tips, and tax: $8.00

Wednesday, June 10

Tour D (Ladies Only) **10:00 a.m.**

Mexico Tour

Across the border to Mexico, via Coronado and the famous Hotel del Coronado. Following a tour including Tijuana and Calien e and luncheon at La Sierra, you'll have a chance to bargain for imported perfumes and native handicrafts or just to browse in Tijuana's arcades before returning to San Diego.

Tour, luncheon, tips, and tax: $5.00

Tour E **6:30 p.m.**

Balboa Park Dinner and Theatre Trip

Dinner on the patio at the Cafe del Rey Moro; then a short stroll under the eucalyptus trees to the Old Globe Theatre, a modern replica of Shakespeare's original to see "The Man Who Came to Dinner."

Dinner, theatre, tips, and tax: $6.00

Thursday, June 11

Tour F **11:30 a.m.**

San Diego Zoo

A visit to the San Diego Zoo and luncheon in the Zoo's restaurant. A bus tour to see all of the exhibits and time to revisit your favorites on foot.

Luncheon, tour, tips, and tax: $4.00

Friday, June 12

A free day for your own exploration of San Diego's beaches, fishing, sailing, museums, etc. Hostesses will have suggestions and information available on various activities.

57 Exhibits Set for Second Annual ARS Western Astronautical Exposition

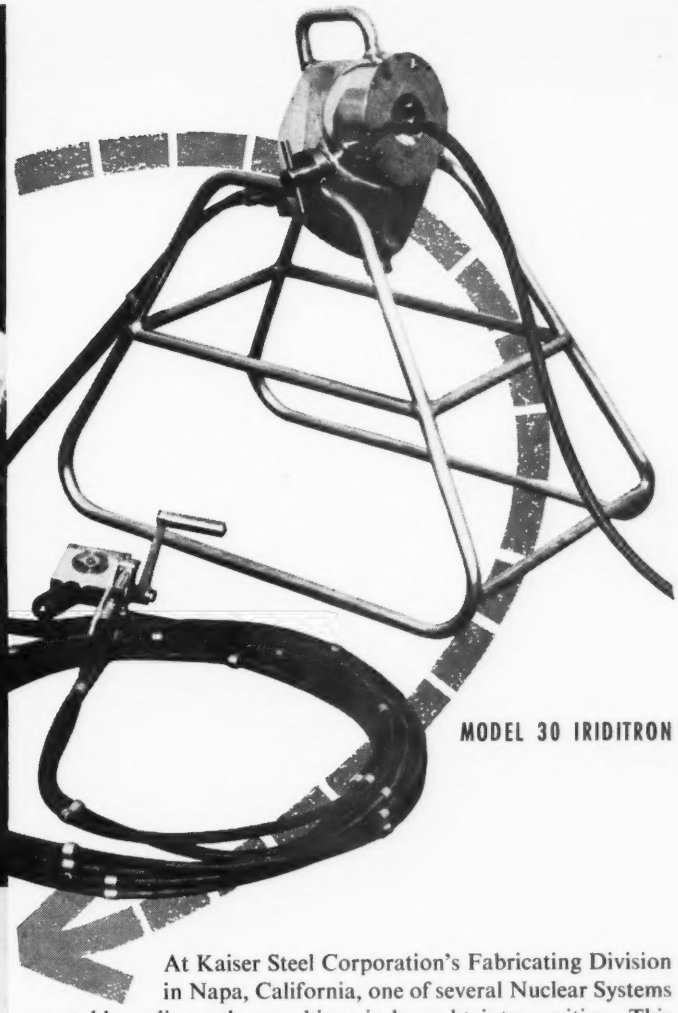
A total of 57 exhibitors will display products, components, and equipment at the Second Annual ARS Western Astronautical Exposition, to be held June 8–12 across the street from the El Cortez Hotel in San Diego, Calif., in conjunction with the ARS Semi-Annual Meeting.

The complete list of exhibitors and booth numbers follows:

Booth	Exhibitor
7	Accessory Products Co.
55	Adel Precision Products
58–59	Aerojet-General Corp.
32	Aeronutronic Systems, Inc.
48	Aeroproducts Operation, Allison Div. of General Motors
37	Aeroquip Corp., Marman Div. and Western Div.
69–70	Astrodyne, Inc.
51	Autonetics Div. of North American Aviation
1	Avco Research & Advanced Development Div.
14	Beckman & Whitley, Inc.
89	Bendix Aviation Corp.
56	Berndt-Bach, Inc.
43	Blaw-Knox Co.
81	Brush Instruments Div., Clevite Corp.
76–77	Burroughs Corp.
88	Callery Chemical Co.
40-41	Cleveland Pneumatic Industries, Inc.
53–54	Consolidated Electrodynamics Corp.
60–61	Convair Div. of General Dynamics Corp.
87	Deutsch Fastener Corp.
71–72	Douglas Aircraft Co., Inc.
44	Dynamic Research, Inc.
57	Food Machinery & Chemical Corp.
34	Futurecraft Corp.
33	The Garrett Corp., Air Research Mfg. Div.
65–67,91	General Electric Co.
90	General Electric Co., Rocket Engine Section
5	Haveg Industries
45–46	Hydromatics, Inc.
18,20–21	International Telephone & Telegraph Corp.
25	James, Pond & Clark Inc.
83	Walter Kidde & Co., Inc.
74–75	Lockheed Missile Systems Div.
86	McCormick Selph Associates
12	Marquardt Aircraft Co.
79	The Martin Co.
10	Minnesota Mining & Mfg. Co.
3	Menasco Mfg. Co.
24	Neff Instrument Corp.
49	Norris-Thermador Corp.
26	Parker Aircraft Co.
27	Parker Seal Co.
22–23	Pratt & Whitney Aircraft Div. of United Aircraft Corp.
28–29	Raytheon Mfg. Co.
39	Robertshaw-Fulton Controls Co.
16	Rocketdyne Div. of North American Aviation
30	Solar Aircraft Co.
62–63	Thiokol Chemical Corp.
47	United Electrodynamics
8	Victor Equipment Co.
35	Western Gear Corp.
68	Weston Hydraulics, Ltd.
42	E. B. Wiggins Oil Tool Co., Inc.
9	John Wiley & Sons, Inc.
84–85	Wyman-Gordon Co.
15	Zero Mfg. Co.

COMPLETING THE PICTURE . . .

Nuclear Systems Economical, Portable Radiography Machines



MODEL 30 IRIDITRON

At Kaiser Steel Corporation's Fabricating Division in Napa, California, one of several Nuclear Systems portable radiography machines is brought into position. This man is using a light, easily carried Model 30 with an Iridium 192 source to spot-check plate welds on the bow section of a steel barge. The steel is a half inch thick.

Companies all over the country are saving time and money . . . keeping weld quality high . . . by inspecting with radiography machines from Nuclear Systems.

If you have an inspection problem, Nuclear Systems has a safe, portable, economical radiography machine to suit your needs. For full information, contact Dept. A-6 at one of our sales offices. Also . . . inquire about Nuclear Systems regularly scheduled three-day Radiation Health Physics Course — an approved AEC licensing aid.

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Attendance of 500 Marks Controllable Satellites Conference at MIT

The Controllable Satellites Conference co-sponsored by ARS and the Massachusetts Institute of Technology, and held on the MIT campus and at the Hotel Statler-Hilton in Boston April 30–May 1, proved to be a highly successful one, attracting an attendance of 500.

Under the able direction of Peter H. Rose of Avco, general chairman of the conference; John T. Harvell of Arthur D. Little, ARS New England Section president; and program co-chairmen George P. Sutton of MIT and Gerald A. Ouellette of Raytheon, a program was assembled which held the attention and interest of all those in attendance and was provided with the sort of platform a conference of this type requires.

The four technical sessions were held in MIT's impressive Kresge Auditorium (a building as modern as the subjects under discussion), which provided a perfect backdrop for the stimulating discussions produced by many of the papers. Technical sessions covered guidance and control, the external environment in which satellites will operate, vehicle design and recovery, and propulsion of trajectories. In all, 17 papers, almost all of high quality, were presented at the conference.

The guidance and control session which opened the conference was highlighted by another in the long series of arguments on air-supported versus liquid-floated gyros which have marked ARS meetings. This time a hot discussion resulted from a paper on "Performance of Inertial Guidance Components on an Unstabilized Base" (ARS Preprint No. 775-59) delivered by Henry Blazek of Ford Instrument Co., with C. Stark Draper, head of MIT's Aeronautics and Astronautics Dept., plumping for the liquid-floated gyro developed by MIT in space missions, and Blazek backing the ABMA-Ford air-floated type.

One of the more interesting papers at the session devoted to environmental factors was that by R. A. Minzner of Geophysics Corp. of America on the latest data on atmospheric density and temperature measurements, as indicated by recent rocket and satellite experiments (ARS 781-59). The author indicated that these data indicated higher densities and temperatures than those predicted as late as a year ago, after reduction of the first satellite data.

The conference banquet on Thursday evening, April 30, at the Statler-Hilton in Boston, was marked by an attendance of 175 people, who heard the Hon. Overton Brooks (D., La.), chairman of the House Committee on Science and Astronautics, discuss some of the latest developments in the field of astronautics. In his address, Rep. Brooks revealed for the first time that four mice were to be sent into space in the next shot in the Discoverer program, and also provided some hitherto unreleased details about the previous Discoverer launching.

John Harvell delivered the welcoming address at the banquet, while Rep. Brooks was introduced by Maj. Gen. James McCormack (USAF-Ret.), vice-president of MIT and former director of the Institute for Defense Analyses.

George Brady of ARPA provided an insight into military thinking about satellites with a paper on "Application and Uses of Satellites" (ARS 783-59) at the session on vehicle design and recovery. Brady noted that satellites which can be maneuvered or controlled from the ground could carry out missions of a "defensive or deterrent nature," and could provide a first line of defense against hostile attacks. He also revealed that rocket systems now under development will be capable of placing satellites weighing several tons in orbits as high as 22,300 miles above the earth.

Another interesting paper at this session was delivered by John K. Wall of Douglas Aircraft in a discussion of "The Feasibility of Aerodynamic Stabilization of a Satellite Vehicle" (ARS 787-59), in the course of which he pointed out that drag devices such as balloons or kites might be used to provide proper orientation of satellites in space. In an addendum to a paper on "Use of Aerodynamic Lift during Entry into the Earth's Atmosphere" (ARS 785-59) by Lester Lees, Fred W. Hartwig, and Clarence B. Cohen of Space Technology Labs, the authors suggested that a re-entry vehicle with a lift/drag ratio of 2.0, and landing controls comparable to present launching controls, could start re-entry at a point some 500 miles off the West Coast and subsequently maneuver to any point within the U.S. proper, as well as points in Canada or Mexico.

The propulsion session was devoted primarily to advanced propulsion systems, with ion rockets singled out for special attention in a paper by Russell N. Edwards and Harold Brown of GE (ARS 789-59), who stated that small ion systems could be ready for limited testing in space as early as 1961, with larger systems available three or four years later.

ARS New England Section officers and members, MIT personnel who graciously made available the university's many facilities during the conference, Fred Durant of Avco, in charge of press relations, and Ben Bova, his able assistant, all had a hand in making the meeting an outstanding success.

—I.H.

ARS Receives NSF Grant For Russian Translations

The AMERICAN ROCKET SOCIETY has received a $30,200 grant from the National Science Foundation for support of the translation and publication of selected Russian material in the field of astronautics for a one-year period. Present plans call for publication of about 200 pages of such translations in the ARS JOURNAL during the coming year.

SECTIONS

Alabama: At the March meeting, which was well attended by both ARS and RCAA members, **Harry O. Ruppe** of ABMA gave an informative lecture on the prospects for lunar exploration. Guests **S. K. Hoffman** and **Roy Healy** of Rocketdyne had some interesting comments to add to this presentation.

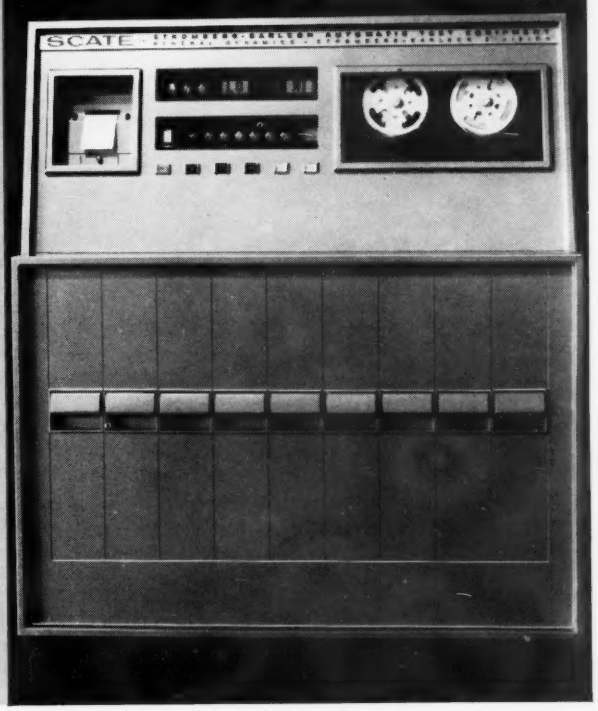
In the April meeting, **S. J. Gerathewohl,** chief scientist for bioastronautical research at AOMC, discussed zero-gravity experimentation and its importance in preparing for manned spaceflight. Dr. Gerathewohl received the Aero Medical Assn.'s Arnold D. Tuttle Award for space research in 1958. His talk was both informative and thought-provoking, as it appears that no one really knows yet what the effects of prolonged weightlessness will be.

Central Colorado: At the March meeting, members heard **Dandridge M. Cole,** senior advanced planning specialist of Martin-Denver, discuss lunar colonization. Cole believes that the advantages of having permanent colonies on the moon far outweigh the disadvantages; that good reasons for such colonies are to support military bases, research laboratories, and health and tourist resorts; that advances in rocket propulsion technology already scheduled will allow permanent bases on the moon by 1970 and full colonies by 1980; and that travel to the moon will be commercially practical by the same time.

—Robert W. Rhoades

Columbus: The March meeting, held at Battelle Memorial Institute, featured a visit and talk by ARS President **Col. John P. Stapp,** who discussed "Acceleration in Space" and

A TALENT FOR WEAPONS TEST EQUIPMENT



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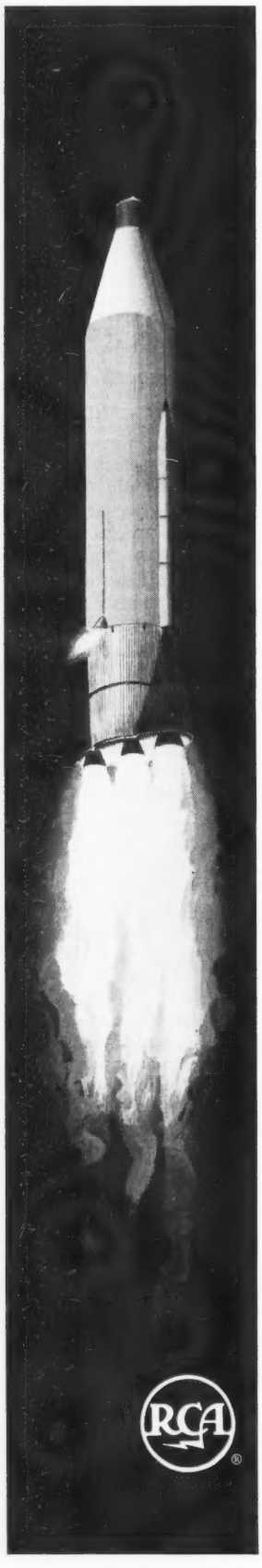

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showed movies and slides on sled tests, protective clothing, and weightlessness experiments. At one point, he brought out that weightlessness runs with aircraft have shown that fluids develop large entrapped bubbles and also tend to break into globules in the weightless state. This will present problems in the design of hydraulic systems for space vehicles. He also mentioned that flights have been made to obtain data at the simulated gravitational field strength of the moon.

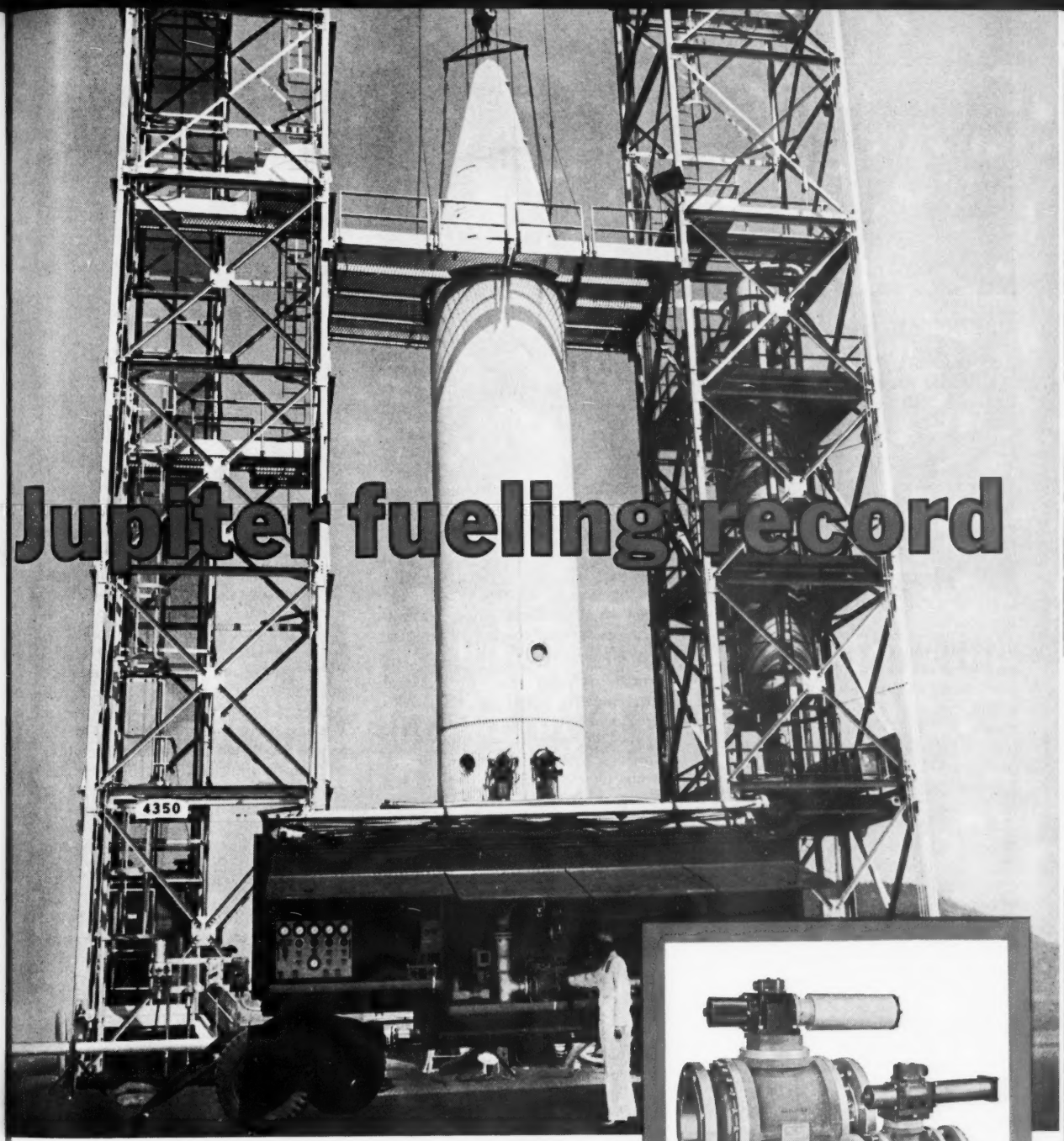
At the March meeting, Loren Bollinger, outgoing section president, announced and presented newly elected officers—Emerson W. Smith, president; James L. Harp, vice-president; Carl F. Speich, corresponding secretary; Tobenette Holtz, recording secretary; and James Colegrove, treasurer.

Some 30 members and guests gathered at Battelle Memorial Institute early in April heard guest speaker **Robert E. Maringer,** assistant chief of Battelle's Metallurgical Engineering Div., discuss "Using Meteorites for Research on Re-Entry." Because meteorites have a structure which has stabilized over thousands of years at the low temperatures of outer space, he noted, the aerodynamic heating caused by entry into the earth's atmosphere produces marked structural changes. By analyzing a cross section of the meteorite and then matching this structure with an artificially heated core sample of the same meteorite, quantitative data have been obtained on re-entry temperatures, heat gradients beneath the surface, and amount of surface ablation. This interesting talk was illustrated by slides showing microscopic structure of meteorite samples and plots of re-entry data obtained from these samples in an Air Force sponsored research project conducted by Battelle. A question period and refreshments followed the talk.

—Tobenette Holtz

Chicago: At the March meeting, guest speaker **William Patterson,** president of United Air Lines, discussed advances in commercial jet aircraft and their impact on travel. He lauded the skill of modern pilots, and pointed out the great responsibilities they bear in taking aloft as many as 150 passengers in an aircraft representing an investment of many millions of dollars. He also said that his company plans to buy some half-billion dollars worth of new jet aircraft in the next five years. The members, many of whom have a long standing interest in the application of jet propulsion to commercial aircraft, found this a stimulating talk.

Connecticut Valley: Members gathered at Trinity College in March



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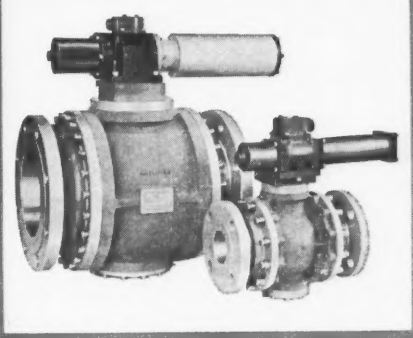

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Gentlemen, Good Fortune

ARS President Col. John P. Stapp looks happy about the propects for space age man as he poses with Columbus section officers, outgoing president Loren Bollinger (left) and incoming president and vice-president Emerson W. Smith and James L. Harp (right).

to conduct business and to hear guest speaker **Robert Ellison,** a supervisor of applied physics for Reaction Motors Div. of Thiokol Chemical, give an illustrated discussion of advanced propulsion concepts. This program drew a good turnout and was well received.

Kansas City: About 70 members and guests attending the April meeting heard **P. Whitson Godfrey,** project group engineer of McDonnell Aircraft, speak on "Solid Rocket Motor Systems." His informative and colorful presentation included some startling pyrotechnics with samples of solid propellant. He reviewed the historical background of solid fuels; presented some of the basic theory applicable to their use; described several currently operational solid propellant missile systems; and discussed the complexity and immense size of manufacturing facilities for the production of solid motors.

The section is presenting the Univ. of California "Space Technology Lecture Series" in Kansas City. The lectures are being given several evenings each week to make them readily available. Many other technical and professional societies as well as local colleges and universities cooperated in publicizing the series. The general interest in space technology can be seen in the course enrollment—some 600 as compared with section membership of 150. The series began April 9 and will run 17 weeks.

—R. W. Fetter

Maryland: In a February dinner meeting, members and guests had the pleasure of hearing **Milton Rosen,** NASA's chief of rocket vehicle development, discuss aspects of the national space vehicle program. This was an exciting presentation, indicating the breadth and depth of the burgeoning NASA projects. Later many of those in attendance toured the facilities of Aircraft Armaments Inc. at Cockeysville.

New York: As part of its educational program, the section is studying a plan to give a symposium on celestial dynamics in New York City. The section is also investigating ways to enlarge its services to student chapters in the area.

Northern California: At a March dinner meeting held in Palo Alto, guest **J. P. Layton** addressed the members on the needs for research in jet propulsion. He related many humorous incidents from his long experience in rocket research—starting with the U.S. Navy in 1941, where he was in charge of solid propellents in connection with the Jato program, later with the Viking and Demon projects with the Glenn L. Martin Co., and now on the staff of the Dept. of Aeronautics at Princeton Univ. He also outlined some of his ideas on the importance of work in the fields of high energy chemical reactions, combustion instability, and the development of scaling laws. He expressed the opinion that nuclear fission reactors, in spite of present problems, will not be denied in the long run, and that lack of knowledge on properties of materials is perhaps one of the most serious bottlenecks at the present time.

The Univ. of California chapter was well represented at the meeting. A. K. Oppenheim was accompanied by Don Christiansen, president-elect of the chapter, Larry Schneider, secretary, Norman Olsen, and Bob Gordon of Aerojet-General.

—C. F. Hansen

North Texas: A good turnout of members and guests at the April dinner meeting, held in Western Hills Inn, heard ARS President **Col. John P. Stapp** talk on "Rocket Age Man" and show movies and slides on current projects to prepare man for space flight. This was an exciting presentation, and much enjoyed by his audience.

Pacific Northwest: At the March meeting, after a no-host dinner and social hour, guest AF **Col. Asa B. Gibbs,** deputy director of the Atlas project, gave a classified talk on Atlas-Score and similar Atlas applications. This proved a most interesting topic.

—Regis A. Hacherl

Sacramento: The March meeting, held at the McClellan AFB officers' club, saw some 350 members, guests, and wives fill the dinner-meeting banquet room, and later hear guest speaker **Chandler C. Ross,** vice-president of engineering for Aerojet-General, discuss nuclear propulsion for rockets. He pointed out that the technical problems involved, with presently available knowledge, would make the development extremely expensive, especially in regard to special test facilities and equipment. To finance this program, he said, the government would be forced to slight current space and defense projects. Thus, present planning is limited to basic studies. The advantages of nuclear propulsion were listed as high specific impulse and huge amounts of power. At the current rate of use, it appears that natural fuels will be so scarce in 25 to 50 years that either nuclear propulsion must be used for rockets or nuclear plants will have to be built to produce electric power to create synthetic fuels.

—Ira Nagin

St. Joseph Valley: Meetings were held at Notre Dame Univ. in February and March. In the February meeting, 75 members and guests saw the following films made available by North American Aviation: "The Supersonic Sled," "Horizons Unlimited," which covered tests of an early research missile, and "Nuclear Reactors for Research." These films proved to be generally informative and interesting.

In the March meeting, some 25 members and guests gathered to hear **Melvin Gerstein,** assistant chief of the Propulsion Chemistry Div. at NASA's Lewis Research Center, talk on some aspects of propulsion chemistry and rocket fuels relating to the national space program.

—Marvin S. Ehrenberg

St. Louis: John R. Hereford, instrument development engineer of McDonnell Aircraft Corp.'s Research Dept., addressed the April meeting on "Astronomical Research." Hereford has been involved in optical instrumentation and flight test programs at McDonnell for several years, during which time he has been engaged in the design of optical instrumentation for

RTV (room temperature vulcanizing) silicone rubber being applied as sealant in Douglas DC-8. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

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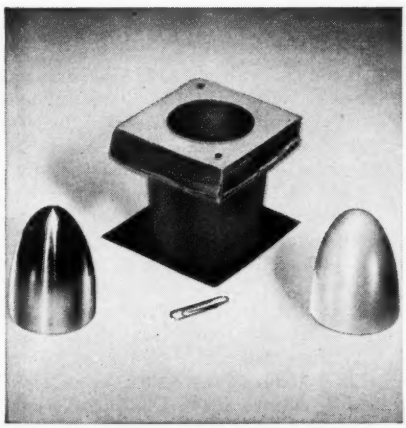
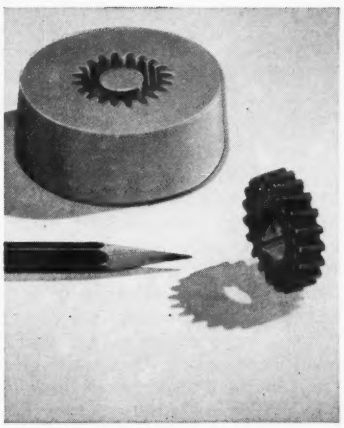


Prototype jet engine nose cone (right) cast in RTV mold. Epoxy parts cast in flexible RTV molds have a bright, glossy surface and reproduce extremely fine detail. No parting agent is required for even the most complex parts. High tensile and tear strength is retained even after prolonged heat aging.



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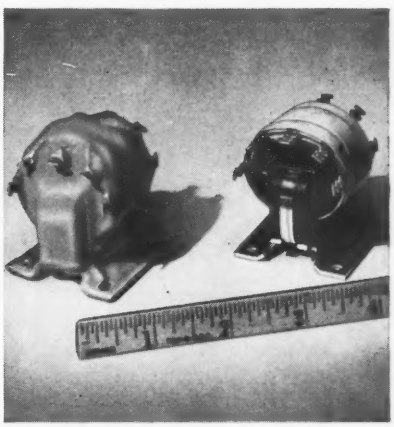

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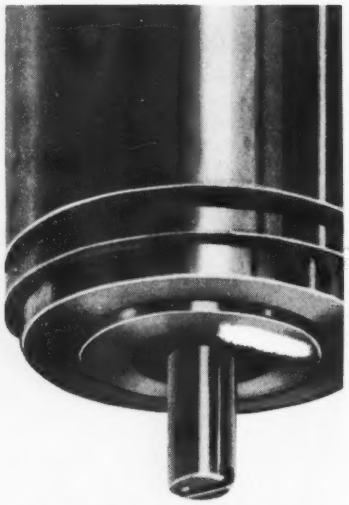

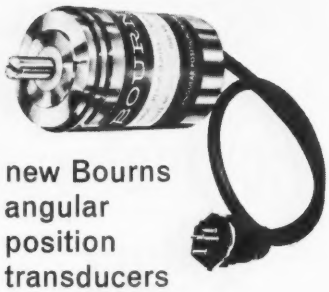

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Output Voltage	0.15 v per degree arc into 10K load
Linearity (20-0-20°)	±0.5%
Operating Temperature	—65° to +250°F
Frame Size	No. 15

Write for complete technical data

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He explained that an obstacle in obtaining a greater amount of astrophysical data is the absorption of the ultraviolet and infrared rays from the sun and other stellar bodies. He suggested that a possible method of overcoming this obstacle was by employing a satellite vehicle with the necessary control and instrumentation to provide a base for a variety of astrophysical experiments. Such a satellite would travel a polar orbit to obtain a maximum period of solar observation. He outlined the problems involved in, and possible solutions to, the controls and instrumentation of such a satellite and its components.

—Al Cohen

STUDENT CHAPTERS

Parks College: At a meeting in February, members had the pleasure of hearing **Col. Morton P. Jaffey** of Redstone Arsenal discuss "Space Law," a rather thorny topic these days. This was an interesting talk, drawing a variety of questions and responses from the members.

At March meeting, **James D. Falk**, preliminary design engineer of McDonnell Aircraft, talked on "Guided Missiles and the Weapon System Concept." After this very informative lecture, he gave an informal discussion concerning job qualifications, opportunities, etc. in industry.

—Donald M. Arndt and Norbert J. Kulpa

Univ. of Virginia: During February and March, the chapter held two meetings and went on a field trip. A February meeting was devoted entirely to business, such as nominations for vice-president, a position vacated by Vernon Wagner on his graduation.

On Feb. 25, members, in a caravan of five cars, journeyed to Norfolk Naval Base, where they were given a tour of the USS Gyatl, a destroyer with a Terrier battery; visited the drone control center; saw operational models of Regulus I, Terrier, Sparrow I, and Talos; and were escorted through the missile repair shop of Oceana Naval Air Station. At this latter installation, the members saw Sparrow III and Sidewinder missiles.

In the March meeting, members heard guest **Roland G. Webster** of Atlantic Research Corp. describe and discuss Arcas, the high altitude sounding rocket under development for the Navy by his company. The members welcomed the chance to hear and to talk with someone intimately involved in a rocket development.

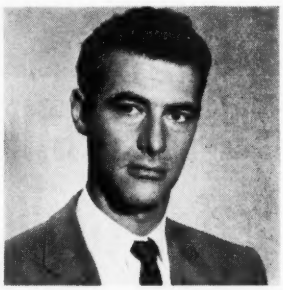
—Stuart L. Croll

Wayne State: Newly elected officers of the chapter are James Wells, chairman; Charles Martin, vice-chairman; Howard Willson, corresponding secretary; Thomas Newton, recording secretary; and Edward Lovell, treasurer. Charles Perry is faculty adviser to the chapter.

—Howard Willson

TECHNICAL COMMITTEES

Communications: Max Lowy, chief systems engineer, Data Control Systems, Inc., has been named chairman of the Communications Committee. Committee members are: Thomas Carr, Arma Div., American Bosch Arma Corp.; Frank W. Lehan, Space Electronics Corp.; Myron H. Nichols, Univ. of Michigan; Myron G. Pawley, U.S. Naval Ordnance Lab; and W. T. White, Sperry Gyroscope.



Max Lowy

Human Factors and Bio-Astronautics: Chairman Lt. Col. Stanley White has announced the make-up of the Human Factors and Bio-Astronautics Committee. Vice-chairman is Eugene B. Konecci, Douglas Aircraft. Members are: Earl T. Carter, Columbus, Ohio; Irwin Cooper, Rand; J. G. Gaume, Martin Co.; S. Gerathewohl, ABMA; R. W. Lawton, Hatboro, Pa.; Frederick Ordway III, Chevy Chase, Md.; H. Schaefer, Navy School of Aviation Medicine, Pensacola, Fla.; Lt. Col. David G. Simons, Randolph AFB; Arnold Small, Convair; Gordon Vaeth, ARPA; F. van der Wal, Space Technology Labs; Capt. Julian Ward, BMD; Gordon Wells, Inglewood, Calif.; Douglas Worf, NASA.

Stanley White

STEPS IN THE RACE TO OUTER SPACE

Nuclear Rocketship

Despite the sky-high transportation costs, Lunar manufacturing should prove economically viable. With unlimited Solar power, controlled atmospheres and advanced automation, a considerable commerce could be realized in delicate instruments, rare minerals, reactor cores and other items that might be more efficiently processed or produced in the Moon's perfect vacuum.

To supply the Moon colonists, and to carry their production back to Earth, special rocketships will be developed. Nuclear energy is the most promising source of propellant power. The ship shown here utilizes nuclear fission for heat and hydrogen gas as a working fuel. From pressurized tanks, the gas is fed through a heat exchanger, expanded, and expelled for the motive thrust.

When the craft leaves Earth, it carries only enough gas for a one-way trip. For, by extracting hydrogen and oxygen from Lunar rocks, Moon settlers will be able to refuel the rocketship for the return voyage. This will permit smaller fuel tanks on the craft and larger payloads.

Inertial navigation systems will play an increasing role in the exploration of outer space. ***ARMA*** is actively supporting the Air Force's program in long range missiles and is in the vanguard of the race to outer space. ***ARMA***, Garden City, N. Y. A Division of American Bosch Arma Corp.

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Radio Guidance

(CONTINUED FROM PAGE 21)

length by making use of the interferometer principle. The diagram on page 21 shows how this is done. The phase difference received at the two ground stations (for a distant space vehicle, the wave arriving at the ground can be considered plane to a very good approximation) relates to the angular position of the missile through the formula

$$\Delta\psi = 2\pi/\lambda\ D \cos\theta.$$

Obviously another receiving station, as indicated in the diagram on page 21, will give angular information in the other plane.

Simple geometry shows that the angular position is given by the following relationships in terms of phase differences between the *N-S* and *E-W* pairs of antennas:

$$\Delta\psi_{E\text{-}W} = 2\pi/\lambda\ D \cos E \cos A$$

$$\Delta\psi_{N\text{-}S} = 2\pi/\lambda\ D \cos E \sin A$$

where, for simplicity, the azimuth is measured with respect to one of the rate legs. By solving for A and E, taking differentials and assuming no dependence between the two pairs of phase differences, we find that the root mean square angular errors are given by:

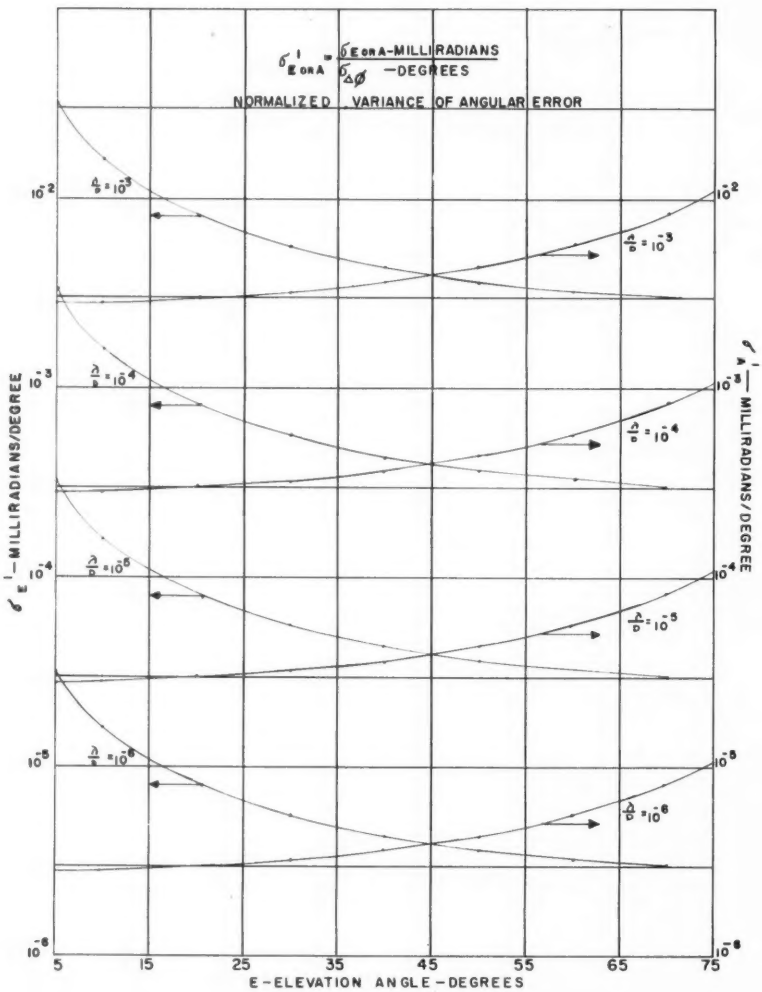
$$\sigma_A = \lambda\sigma_{\Delta\psi}/360^\circ\ D \cos E$$

$$\sigma_E = \lambda\sigma_{\Delta\psi}/360^\circ\ D \sin E$$

In the graph shown below, the ratios $\sigma_A/\sigma_{\Delta\psi}$ and $\sigma_E/\sigma_{\Delta\psi}$ are plotted against E for various values of the ratio λ/D.

Note that ambiguities in angular position can arise, since phase differences are not usually determinable to within multiples of 2π. This problem is overcome in certain systems by the use of auxiliary stations spaced along the baseline, i.e., a number of different D's are used. From phase-difference data obtained simultaneously from pairs of stations, these ambiguities can be resolved. In more sophisticated systems the use of frequency diversity achieves the same results, i.e., a number of different λ's are used.

Angular Error as Function of Elevation Angle and Wavelength to Baseline Ratio

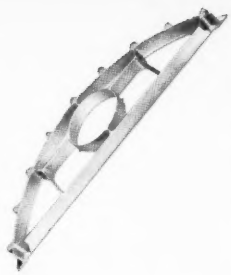


Spurious Value May Result

A very important instrumentation problem which must be solved for the successful operation of this system is that of maintaining phase coherence across the baseline. The signals received at the outer stations must be sent to the central station where the phase differencing is performed. If in this process a small amount of phase error is introduced along the line by any cause whatever, a spurious value for the angular position results. For any interferometer-type system this maintenance of phase (or phase rate) coherence is a critical problem, and various sophisticated electronic techniques must be used to cope with it adequately.

The velocity information could be obtained by differentiating the position data. This procedure can be carried out to a degree of accuracy only if the missile dynamics are fairly well known, since the optimum smoothing procedure that must be used to get the differentiated quantities depends strongly on the specific nature of the motion. Any system which derives the velocity by differentiating the position data will present problems if the thrust program is varied in sudden or discontinuous fashion, as this will strongly degrade the specially designed data handling procedure. Of course, things may also be done in reverse; the velocity can be measured directly and the range and angular position data obtained by integration. However, a simple system such as this suffers from the serious limitation that any temporary loss of signal can introduce an error into the position data in the form of an uncertain constant of integration.

Direct measurement of velocity is obtained by means of the Doppler effect. The relationship between radial velocity and Doppler frequency f_D is given by the expression: $f_D = \dot{R}f/c$, so that we must know not only the Doppler frequency but the original transmitted frequency. When one considers that to ascertain the velocity to within 1 fps, using a frequency as great as 10,000 mc/sec, he must measure the Doppler frequency to within



A REPORT ON THE FIRST SUCCESSFUL PROCESS FOR CHEMICALLY MILLING LIGHT METAL CASTINGS

In high speed jets, rockets, and missiles the price tag on every ounce of excess weight is enormous. Even the use of lightweight aluminum and magnesium alloys wherever possible leaves room for improvement. For while part thickness is often determined by structural requirements, it is frequently a function of the metalworking processes used. Castings, for example, must have sufficient wall thickness to assure sound structure throughout. Thinner sections are generally achieved by machining the parts after casting. This is often an expensive and sometimes impossible task, especially where complex contours or double walls are involved.

Enter Chemical Milling

The first break came when a solution was discovered to the same problem as it affected wrought parts. The solution—familiar to every high school chemistry student—was based on the consumption of metals by powerful reagents. Its successful application to metalworking production presaged significant strides in weight reduction. But when the same techniques were applied to castings, results were extremely poor.

Rolle research immediately began laboratory tests to discover the reason for the failure, and found it often lay *in* the castings. Even minor imperfections in the casting surface unbalanced the process of metal removal—enlarging any defects present. Rolle also found, after much searching, that only certain reagents in certain concentrations—depending on both the part cast and the alloy used—could guarantee success. It has taken almost two years of exhaustive research to refine this process to the extent that it can now take its place as an accepted metalworking technique. Parts can now be designed for casting that could only be constructed by sheet fabrication techniques in the past.

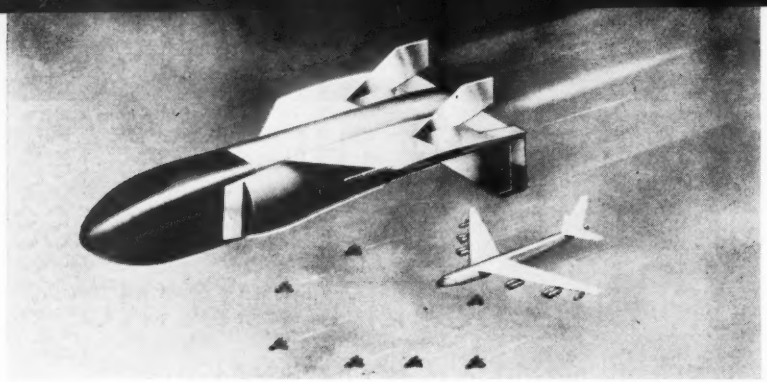
Half The Wall Thickness

The major advantages of this chemical milling process are pretty much wrapped up in the single figure 0.060"—the wall thickness which Rolle can consistently meet by the process. The importance of this figure is readily comprehended by comparing with it the conventional limit on casting wall thickness—.125". Rigid control techniques, developed in the laboratory, even permit an overall improvement in dimensional tolerances of the part as a result of the chemical milling process. And at the same time, surface finishes of an order of 100 microinches or better can be consistently achieved.

There are two ways you can take advantage of this Rolle technique for chemical milling. One requires the controlled removal of metal from the entire surface area of the part. Allowance can be made in the pattern for holding heavy sections and critical dimensions despite chemical metal removal. The other method, useful where the areas to be lightened are relatively limited, requires masking of those areas not to be etched. The proper technique, of course, can only be decided on the basis of the individual part.

Since the success of chemical milling depends to a considerable extent on the soundness of the casting itself, Rolle cannot promise satisfactory results on any but a Rolle cast part. But Rolle will gladly examine your prints and parts in light of this new technique and make recommendations or quote prices, as you desire. Furthermore, we'll be happy to answer any further questions you may have relevant to chemical milling or the sand, permanent mold, shell mold, or investment casting of aluminum or magnesium alloys. Write Rolle Manufacturing Company, 319 Cannon Avenue, Lansdale, Pa., or call ULysses 5-1171.

ROLLE



Quail–Decoy for Bird Watchers

Artist's conception of AF GAM-72 Quail, air-launched diversionary missile developed by McDonnell for SAC use. Equipped with various countermeasures, missile would be launched by B-47 or B-52 on approaching target area.

10 c, the necessity for an ultrastable oscillator is quite apparent.

Techniques are very well developed for measuring radial velocities to less than a foot per second. New atomic or molecular frequency standards now under development offer considerable promise in this field, but at present the size, weight, and vibration problems have not as yet been overcome. Current systems therefore make use of a stable oscillator on the ground which transmits the signal to the vehicle, where it is amplified and retransmitted to the ground. At the central station, the frequency of the signals received at the outer stations with that transmitted from the central station presents the same sort of stability problems that were encountered in describing angular measurements across a long baseline.

Presuming that this problem is satisfactorily solved, the angular velocity components in terms of these range rate differences are given by the following equations:

$$\Delta\psi_{E\text{-}W} = -\ 2\pi D/\lambda$$

$$(\sin E \cos A \dot{E} + \sin A \cos E \dot{A})$$

$$\Delta\psi_{N\text{-}S} = -\ 2\pi D/\lambda$$

$$(\sin E \sin A \dot{E} - \cos A \cos E \dot{A})$$

The root mean square error in $\dot{A}$ and $\dot{E}$ due to independent measuring errors in the phase rate are given by equations identical in form to those for the angular errors:

$$\sigma_{\dot{A}} = \lambda\ \sigma_{\Delta\psi}/360^\circ\ D \cos E$$

$$\sigma_{\dot{E}} = \lambda\ \sigma_{\Delta\psi}/360^\circ\ D \sin E$$

Therefore, the graph on page 66 may be also used to make an estimate of angular rate errors in terms of the error in phase-rate measurement.

It would thus appear that the ideal system is one that measures position and velocity independently, so that no matter how complicated the thrust program may be, or if temporary loss of signal is sustained, independent determinations of velocity and position are obtained. While such systems will of necessity be somewhat more complicated electronically than those which depend on integration or differentiation to supply the position or velocity data, the increase in reliability gained with them should be well worth the extra sophistication.

The Guidance Problem

Having so far described the tracking function, we now return to the guidance problem. The correction commands that are sent to the missile can obviously only alter the vehicle's velocity, in particular the components in the yaw and pitch planes, if we assume that the thrust remains constant. These commands could be sent to the missile via a separate communications channel; but since radar signals have to be sent to obtain the range information, it proves economical to transmit the guidance commands via the same channel. Needless to say, these can be so coded and the receiver on the vehicle so designed that the reception of any other signals but these (i.e., jamming signals) can be made very difficult indeed.

For a highly precise radio guidance system, the degradation in accuracy induced by the atmosphere must be accounted for. The degradation in accuracy can be of two kinds. The first includes those effects resulting from the gradual diminution of the index of refraction (n) with altitude, and the second comprise those due to the dynamical or fluctuating component of the index in space and time.

The most important error resulting from the mean variation in "n" is that in elevation angle. However, this error is serious only for a radar (conical scan or monopulse) which aligns itself with the incoming wave front; for it is readily seen that, with an interferometer type of system which obtains the angular information by measuring phase differences, the angular error results from parallax and horizontal index gradients only. A very good estimate of the error can be obtained on the basis of simple measurements of temperature, pressure, and humidity made on the ground at the receiving stations.

The second category of propagation errors—those arising from the variability of the index of refraction, both in time and in space—are more difficult to deal with. But techniques have been developed for analyzing and measuring these effects, and a system can be designed to take them properly into account. These fluctuating effects are handled as statistical processes and are interpreted on a root mean square basis. For an interferometer system, the easiest way to minimize these sources of errors is to increase the baseline length. In any system, improvements can be obtained by smoothing the observed data over a period of time. It turns out that the smoothing period chosen depends on the mean size of the atmospheric irregularities ("blobs") and their rate of travel across the baseline.

For vehicles very high above the earth in radio contact with the ground, the effect of the ionosphere must be considered. Since the refractive index depends on frequency ($n^2 = 1 - 80\ N_e/f^2$, where N_e is the electron density in meter^{-3}), ionospheric errors are reduced by using very high frequencies. This choice is already implicit in the above equation, since terms describing electron collision frequency and earth's magnetic field effects are missing.

In summary, errors arising from propagation effects are not, at present or in the near future, a limitation on highly accurate radio guidance systems. By a combination of techniques involving meteorological measurements, statistical analyses, proper choice of baseline lengths and smoothing times, a system can be made to perform to a degree of precision set by constraints which are not propagational in origin.

The capabilities of a radio guidance system can be brought more clearly into focus by describing briefly how accurately it can insert a vehicle into a satellite orbit. (For details see the paper "Baseline Guidance Systems" in the IRE Transactions on Military

(CONTINUED ON PAGE 73)

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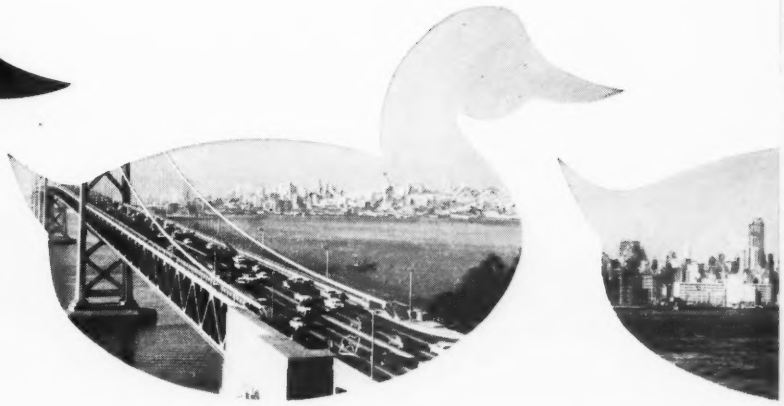
Here are Grumman S2F Trackers on board aircraft carrier, mainstay of United States Navy HUK Group on Anti-Submarine Warfare maneuvers.

S2F starts search with electronic gear that can detect snorkel, periscope, or sub radar, even the submerged sub's disturbance of the earth's magnetic field.

Person
contact

Cities are Sitting Ducks



Coastal cities—of course. Midland cities, too. In fact, any city anywhere in the U. S. is a sitting duck target for missiles launched from subs.

One of the free world's greatest menaces is the submarine.

Best protection against this danger is the U. S. Navy—and its long-range anti-submarine task forces. Fixed-wing long-range aircraft, launched from task force carriers, patrol the high seas, probe their depths, screen their contents. They detect, identify and track. And, upon provocation, destroy. They help make the Navy our strongest defense against the threat of the submarine.

These anti-submarine warfare (ASW) aircraft are operational with the Navy throughout the world. Many are Grumman S2F Trackers. They carry the most advanced electronic detection gear plus the weapons that enable them to perform the complete search-attack assignment.

Grumman

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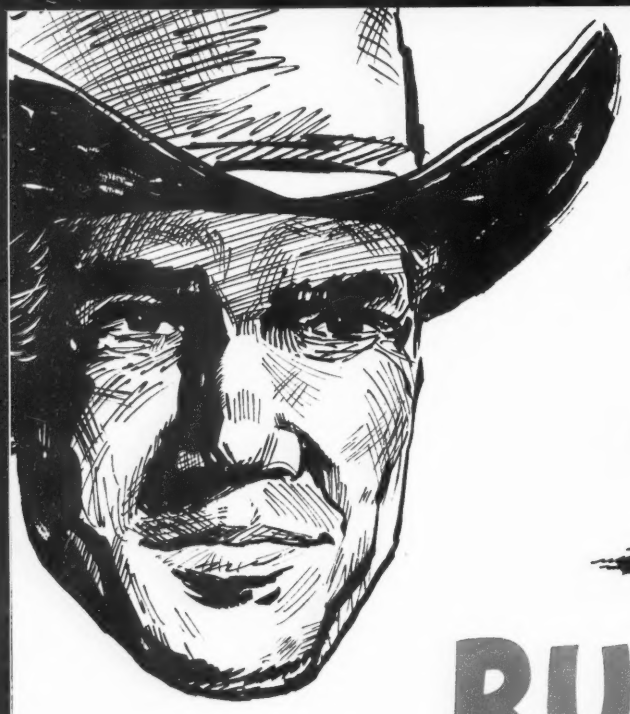
Personnel of Combat Intelligence Center are receiving S2F Tracker report of contact and the dropping of detection devices to pinpoint submarine.

Grumman S2F Tracker is returning to aircraft carrier after "sinking" submarine in war games with depth charges and an ingenious homing torpedo.



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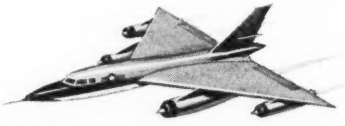
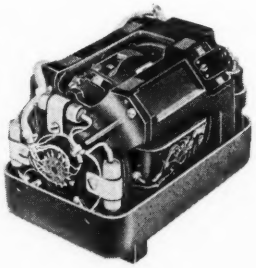


LEAR 1080 SERIES DISPLACEMENT GYRO



LEAR

GRAND RAPIDS DIVISION
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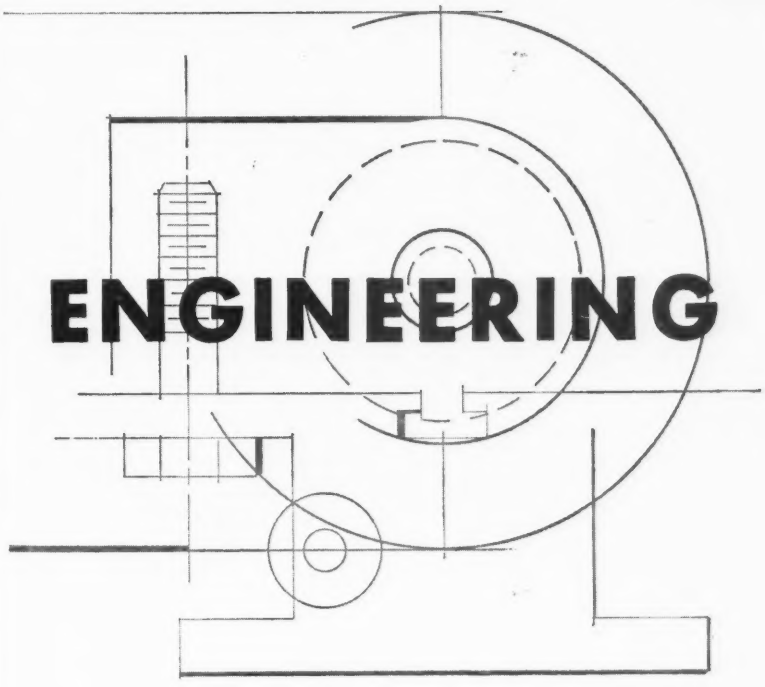
G-5

Electronics, December 1958.) The prescription for accuracy is given in terms of the velocity vector at insertion—its magnitude, direction, and position.

These parameters are expressible in terms of the radar observables—range, range rate, angular position, and angular rates. For simplicity, we take the radar system to be in the trajectory plane so that azimuthal errors may be ignored. The table on page 21 lists some assumed errors in the above radar quantities from which we calculate orbital insertion errors. These errors do not describe any particular systems, but are general "ball park" figures. Note that these are standard deviations describing variable or fluctuating errors; steady-stage or bias uncertainties, while neglected here, must of course be taken into account in practice. In many cases, they can be calibrated out, or otherwise accounted for.

It can be shown that values such as those in the table on page 21 lead to orbit insertion inaccuracies given as altitude ($\sigma_{ho} = 4800$ ft), speed ($\sigma_{vo} = 10$ fps), and velocity direction ($\sigma_{\beta_o} = 2.3\ mr = 0.13°$). All of the errors in the table do not contribute equally to the above insertion uncertainties. They are relatively insensitive, for example, to the radar range error. Decreasing the numbers in the table by, say, a factor of 10 would decrease the errors correspondingly. It is not difficult to see how the insertion errors propagate around the orbit and affect position and arrival time at a given tracking site.

In conclusion, radio guidance offers a highly accurate means for inserting into orbit space vehicles of all kinds. Some current systems, for example, are capable of impacting a space probe on the moon to within less than 100 miles of a designated point. As accuracy requirements become more demanding, baseline lengths can be increased, real-time data smoothing periods can be lengthened and instrumental precisions of the ground equipment can be improved. Special techniques, such as third-stage satellite orbiting prior to fourth-stage escape, can be used for outer space probes to increase the period of observation, and hence precision of ephemeris determination. With such information, very accurate vernier control via radio commands can be obtained and the command for last-stage cutoff timed very accurately. New techniques utilizing ultrastable atomic frequency standards both in the vehicle and at the ground stations offer possibilities for radio guidance simplification and even higher accuracy.



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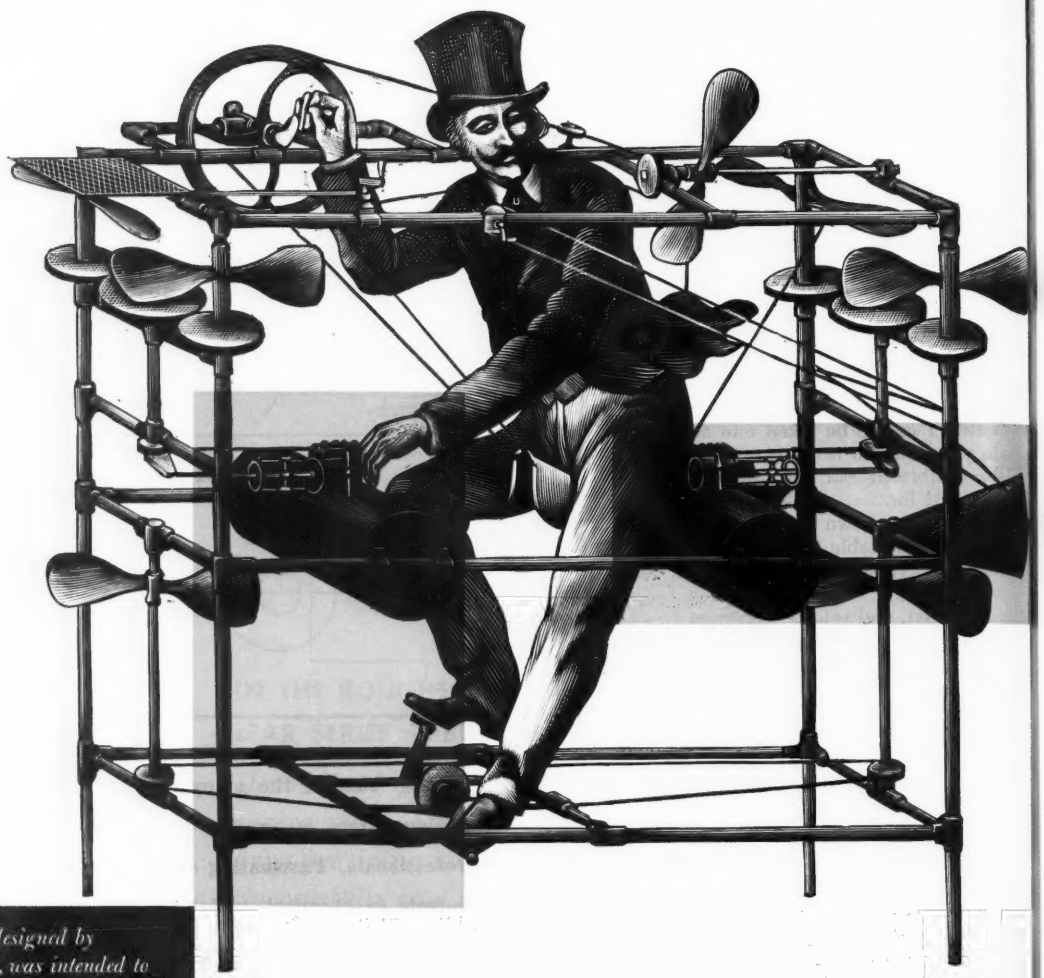

yres' Aerial Machine, designed by r. W. O. Ayres in 1885, was intended to l off the ground through compressed air nerated by foot power. In this illus- ation of the machine, Brussel-Smith, ted graphic artist, has used his ique wood engraving technique to depict -This advertisement another of n's efforts to find the power necessary sustained flight.

IMAGINATION IN SPACE

Since Creation, man has looked out on space. At first, unknowing and incurious; then with the beginnings of understanding; now free and able to explore. Yet to move in space calls for wholly new concepts of energy.

This, then, is the working philosophy of Hercules in chemical propulsion: To design and manufacture highly concentrated packages of energy as propellants and rocket motors; each compatible, controllable, predictable; and each perfected for its specific mission.

HERCULES' BACKGROUND: A half-century of creative imagination in the evolution of propellants, from shotgun powder to the manufacture of every one of the millions of U. S. rockets fired during World War II, and now to space propulsion. Hercules facilities today encompass research, design, engineering, and staff organization for the production of the most advanced propellants. Illustrated brochure available on request.

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People in the news

APPOINTMENTS

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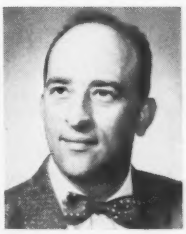

Stoolman

Lt. Gen. Bernard A. Schriever, former commander of AF Ballistic Missiles Div., has been named head of Air Research and Development Command, succeeding **Lt. Gen. S. E. Anderson,** who has taken over at Air Materiel Command, Wright-Patterson AFB, Ohio. **Brig. Gen. Osmond J. Ritland,** vice-commander, BMD, moves up to commander.

Adolph Oberth, son of Hermann Oberth, pioneer rocket expert, has joined the solid propellant research and development staff of Aerojet-General's Solid Rocket Plant. **Robert F. Brodsky,** former Convair-Pomona aerodynamics chief, joins the Aerojet Systems Div. as manager, Engineering Services Dept., Weapons Systems, while **Rear Adm. L. C. Baldauf** (Navy-Ret.), former director of quality control, Navy BuOrd, becomes a technical specialist on Aerojet's quality control staff. **Harry S. Myers Jr.** has been promoted from senior staff engineer, Systems Div., to special assistant to Chandler C. Ross, vice-president, engineering.

John W. Townsend Jr., formerly chief of NASA's Space Sciences Div., has been appointed assistant director for space sciences and satellite applications of NASA's new Goddard Space Flight Center, Greenbelt, Md. **John T. Mengel,** former head of the Space Tracking Systems Branch in the Vanguard Div., has been named assistant director for tracking and data systems, and **Robert R. Gilruth,** current head of Project Mercury, becomes the Center's assistant director for manned satellites.

Richard E. Horner, who resigned June 1 as assistant secretary of the Air Force for R&D, has been appointed NASA associate administrator, **Clark T. Randt** has been named scientist for space medical research in the Office of Research Grants and Contracts. **A. L. Antonio** and **John A. Drake,** have been appointed to the Research Advisory Committee on Chemical Energy Processes; **M. U. Clauser, Gordon Banerian,** and **A. John Gale** to the Committee on Electrical Power Plant Systems; **Lawrence L. Gilbert,** to head the Committee on Materials; **Allen E. Puckett,** to the Committee on Control, Guidance, and Navigation; **Leo Stoolman,** to the Committee on Structural Loads; **Robert D. Fletcher,** and **Brig. Gen. Glen B. Birchard,** to one of the new Research Advisory Committees.

Keith G. Britton joins Atlantic Research Corp. as assistant to the vice-president in charge of the Project Engineering Div. and U.S. Flare, a West Coast affiliate. **George Frederick Kirchoff Jr.** has joined the Project Engineering Div.

AOMC Scientists and Engineers Honored

Twelve top scientists and engineers of the Army Ordnance Missile Command were presented the Department of the Army's highest civilian award, the Exceptional Civilian Service Decoration, by Undersecretary of the Army Hugh M. Milton, shown first row next to AOMC Commanding General J. B. Medaris, in a ceremony at Redstone Arsenal, Ala. Eleven of the recipients are members of the missile and space team headed by Wernher von Braun, second row, third from left, which has been largely responsible for the Jupiter IRBM and for launching the Free World's first earth and sun satellites. Award recipients include: Third row, from left, **Robert W. Cuthill,** chief engineer, AOMC; **Eberhard F. M. Rees,** deputy director, Development Operations Div., ABMA; **Kurt H. Debus,** director, Missile Firing Lab, ABMA; **Ernst D. Geissler,** director, Aeroballistics Lab, ABMA; and **Walter Haeussermann,** director, Guidance and Control Lab, ABMA. Fourth row; from left, **Ernst Stuhlinger,** director, Research Projects Lab, ABMA; **Erich W. Neubert,** director, Systems Analysis and Reliability Lab, ABMA; **William A. Mrazek,** director, Structures and Mechanics Lab, ABMA; **Hans H. Maus,** director, Fabrication and Assembly Engineering Lab, ABMA; **Hans Hueter,** director, Systems Support Equipment Lab, ABMA; **Helmut Hoelzer,** director, Computation Lab, ABMA; and **Karl L. Heimburg,** director, Test Lab, ABMA.

Dorrance

Lepre

Bramhall

Dornberger

Domonkos

Zeigler

Allen F. Donovan, vice-president of Space Technology Labs, has been named director of advanced systems planning, with full responsibility for advanced ballistic missiles and space systems planning. **George J. Todd** has been made test supervisor of the Minuteman program at Edwards AFB, in addition to manager of STL's Edwards Field Office. **Robert Bromberg** and **Arthur F. Grant** have been upped to director and assistant director, respectively, of the propulsion Lab, R&D Div.

Burt D. Taylor, former project engineer for an advanced missile design study at the Missile Div. of North American Aviation, has been appointed chief engineer, Defense Div., Interstate Engineering Corp.

E. Finley Carter, Stanford Research Institute director, becomes its first president, and will serve on the executive committee of the board of directors, while **Weldon B. Gibson,** associate director, becomes vice-president and a board member. **Don R. Scheuch** has been promoted from manager, Weapons Systems Lab, to assistant division director, and will be succeeded by **Henry P. Blanchard,** former head of navigation-aids research.

Roy Smelt, director of research at Lockheed's Palo Alto Lab, has been made manager of the Discoverer satellite project, Missiles and Space Div. **John P. Nash,** associate director, communications and controls, succeeds Smelt. **Kenneth Larkin,** former associate director of research for product development, assumes the same post for electronics research and development, and **E. I. Bricker** becomes division engineer of Lockheed-Georgia's Engineering Research Labs.

Robert W. Bratt and **James S. Murphy** have been named chief and assistant chief, respectively, of Douglas Aircraft's new Aerophysics Lab. In other appointments, **K. Buchele** becomes chief of quality control, Santa Monica Div.; **H. O. Williams,** staff assistant to F. T. Wood Jr., Santa Monica product reliability manager; and **R. G. Paul,** assistant chief, Santa Monica quality assurance and manufacturing reliability. **C A. Seil** succeeds Buchele as supervisor of the nonmetallic materials section in materials research and process engineering.

Max W. Burrell, a vice-president of Collins Radio Co., has been named president of its newly formed subsidiary, Alpha Corp., Dallas, Tex. **John D. Nyquist,** former executive director of Collins Systems Div., becomes vice-president and general manager; **R. M. Ringoen,** engineering vice-president; and **Jack E. Froehlich,** former program director of JPL's earth satellite and lunar probes, vice-president in charge of special projects.

Grayson Merrill, general manager of the Astrionics Div. of Fairchild Engine and Airplane Corp., has been made project manager for the SD-5 drone being developed for the Army by the company. **Louis Bradley** joins the division as chief of the laboratory division of the Engineering Dept.

Leonard Mautner, former president of Electronic Control Systems Div. of Stromberg Carlson Co., has been appointed project manager for special systems at Hughes Aircraft.

William H. Dorrance, former assistant to the director of scientific research at Convair, has been promoted to senior staff scientist in the Convair Scientific Research Lab.

Frank G. Denison has been named manager of vehicle technology of Aeronutronic Systems Space Technology Div.

Jack F. Lepre has been appointed to the new post of vice-president in charge of industrial relations and special projects for Reeves Instrument Corp.

Ervin H. Bramhall, systems analyst with the Weapons System Evaluation Group of the Institute for Defense Analysis, joins Solar Aircraft Co. as chief of weapon systems analysis. **Cyrus C. Haynie** becomes assistant to the San Diego plant manager.

Walter R. Dornberger, technical assistant to the president of Bell Aircraft, has been named director of engineering at the Niagara Frontier Div., while vice-president **Julius J. Domonkos,** former manager of the Aircraft Div., has been appointed vice-president, manufacturing, in Bell's corporate office.

Heinz A. Gorges, principal officer of the Wind Tunnel Group at the Weapons Research Establishment, base station to Woomera Rocket Range, has joined ABMA's Aeroballistics Lab under a one-year consultant contract.

Julius P. Zeigler, former chief of chemicals, propellants, and explosives engineering development for the Army Ammunition Command, has been appointed manager of Celanese Chemical Div.'s new high energy materials operations for missile propulsion systems.

Hugh S. Ferguson succeeds **Richard S. Morse** as president of National Research Corp. Morse resigned to become director of research and development for the Army.

Osmund T. Fundingsland, former manager of Sylvania Electric Products, Inc., Microwave Physics Lab, has been named director of research for Raytheon Mfg. Co.

George W. Griffin Jr. and **George P. Norton** have been elected vice-presidents of General Telephone & Electronics Corp.

James L. Anast and **K. Robert Hahn** have been elected president and executive vice-president, respectively, of Lear, Inc. **Andrew F. Haiduck** and **Roy J. Benecchi** have been elected to the new office of group vice-president; **Joseph M. Walsh** succeeds Benecchi as general manager of Grand Rapids Div. **Louis A. Payne,** former Convair senior dynamics group engineer, joins the Astronics Div., as manager of its Engineering Div.

Charles E. Bartley, former founder and president of Grand Central Rocket Co., has been named president of Rocket Power, Inc., a recently organized subsidiary of the Gabriel Company which will produce solid fuel for moderate-thrust rockets and missiles.

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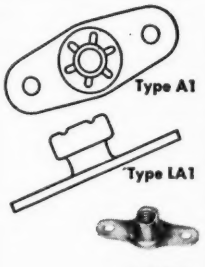

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UNITED AIRCRAFT CORPORATION

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It's a Goddard Year

(CONTINUED FROM PAGE 37)

lished material, will be published next year, and that there is every possibility that the famous Goddard notebooks and correspondence dealing with rocketry will also see early publication.

And there are growing indications that this is only the beginning, and that considerably more in the way of honors will be coming to the quiet, dedicated man who has become famous as the father of modern rocketry.

Announcement of the ARS Goddard Memorial, as well as the Goddard Space Flight Center, came at the Society's Controllable Satellites Conference at MIT (see page 58). The announcement was made by Rep. Overton Brooks (D., La.), chairman of the House Committee on Science and Astronautics, featured speaker at the Conference banquet on April 30.

An ARS Goddard Memorial Fund has been established, and a fund-raising drive is expected to get underway shortly. Former ARS President Fred Durant of Avco is chairman of the Goddard Memorial Committee. Full details concerning the memorial will be released in the near future. Present plans call for some of the nation's top sculptors to submit proposed designs for the memorial to be located on a site in Worcester.

Goddard Center

The Goddard Space Flight Center, to be built on a 550-acre tract acquired from the government's Beltsville Agricultural Center, north of Washington, D.C., will perform basic astronautical research and hold responsibility for development of satellites, space probes and vehicles, tracking, communications, and data reduction systems. In addition, the center will eventually be a command control center for NASA's spaceflight operations. The first two buildings of the Center are expected to be completed by mid-1960.

Dedication of the Goddard Wing at the Roswell Museum was marked by impressive ceremonies and the presence of a host of dignitaries, including Hugh M. Milton II, Under Secretary of the Army; Robert Merriam, deputy assistant to President Eisenhower; Gov. John Burroughs of New Mexico; Wernher von Braun; Mrs. Robert H. Goddard; Phillip S. Hopkins, director of the National Air Museum, Smithsonian Institution; and top military and industrial brass. Col. John P. Stapp, ARS president, was unable to attend, having narrowly escaped death after parachuting from a crippled jet while en route to an ARS Colorado Section meeting after which he was scheduled to go to the dedication ceremonies.

The imposing exhibit, assembled by Roswell Museum Director David Gebhard, brings together large amounts of Goddard hardware, including a number of rockets worked on by Dr. Goddard during his stay in the Roswell area, as well as photomurals of his work. The Goddard launching tower, as well as some of the larger Goddard rockets, are on permanent display in the museum grounds, along with some modern rockets.

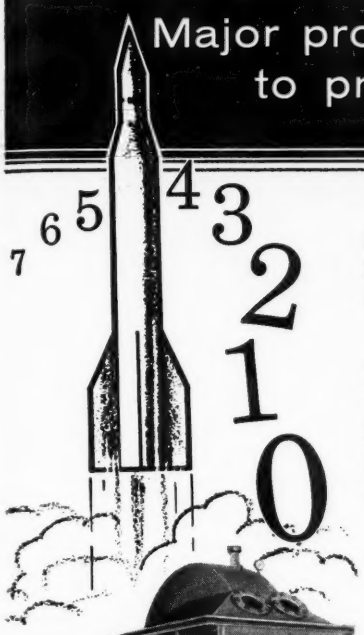
The formal dedication ceremonies, held at de Bremond Stadium adjacent to the Museum, was highlighted by a thoughtful tribute to Dr. Goddard by Dr. von Braun (see page 36), as well as a message from the President delivered by Merriam, and addresses by James McRae, AT&T vice-president; Randolph Lovelace, director of the Lovelace Clinic and chairman of the NASA Life Sciences Committee; Milton; and Mrs. Goddard.

Students and faculty of Worcester Poly paid homage to one of the school's leading alumni at ceremonies marking the dedication of its Goddard exhibit, to be permanently installed in the WPI's mechanical engineering building. The exhibit consists of four large photomurals and some early Goddard rocket hardware.

The dedication ceremonies were opened by Philip Puddington, president of the WPI Senate, who turned the microphone over to Fred Costello, representing the student branches of the school's professional societies. He, in turn, introduced Arthur W. Bronwell, Institute President, who delivered the welcoming address and introduced the featured speaker, Mrs. Goddard. Mrs. Goddard spoke warmly of her late husband's relations with WPI, noting that it was while he was at the Institute that his early ideas were nurtured and crystallized, and it was here also that he did his first research work.

Guests at the dedication ceremonies included George P. Sutton, ARPA chief scientist and immediate past president of ARS; classmates and friends of Dr. Goddard; and representatives of Clark Univ., where he taught and performed many of his early rocket experiments.

Major producers count on **DAY** equipment to process solid propellant fuels



DAY builds equipment specifically designed to meet the exacting requirements for processing solid propellant fuels. The machine types shown here have been specified by major producers of solid fuels for their safe and efficient operation, ruggedness and thorough dependability.

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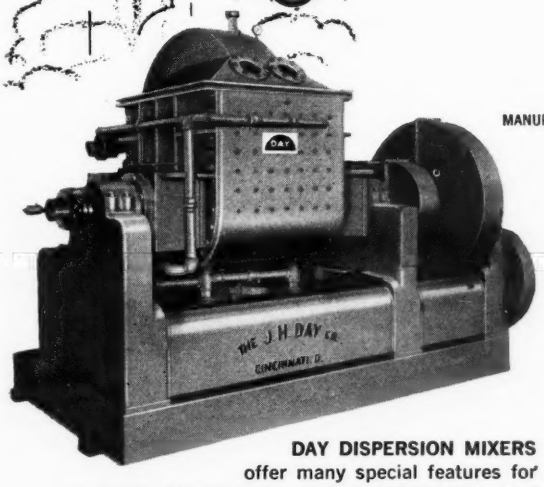

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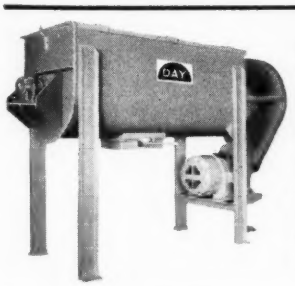
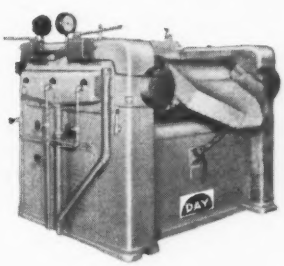
DAY PONY MIXERS twin or single motion, provide fast, thorough mixing of curing agents and high performance fuel additives Whatever your requirements, there's a DAY Pony Mixer specifically designed to do the job. Write for Bulletin 500.



DAY RIBBON BLENDERS provide fast, pre-blending of oxidizer grain sizes prior to final dispersion mixing of the composite fuel. Built in a wide range of rugged tank sizes and designs, with various types of agitators. Write for Bulletin 800.



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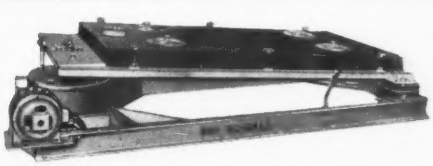

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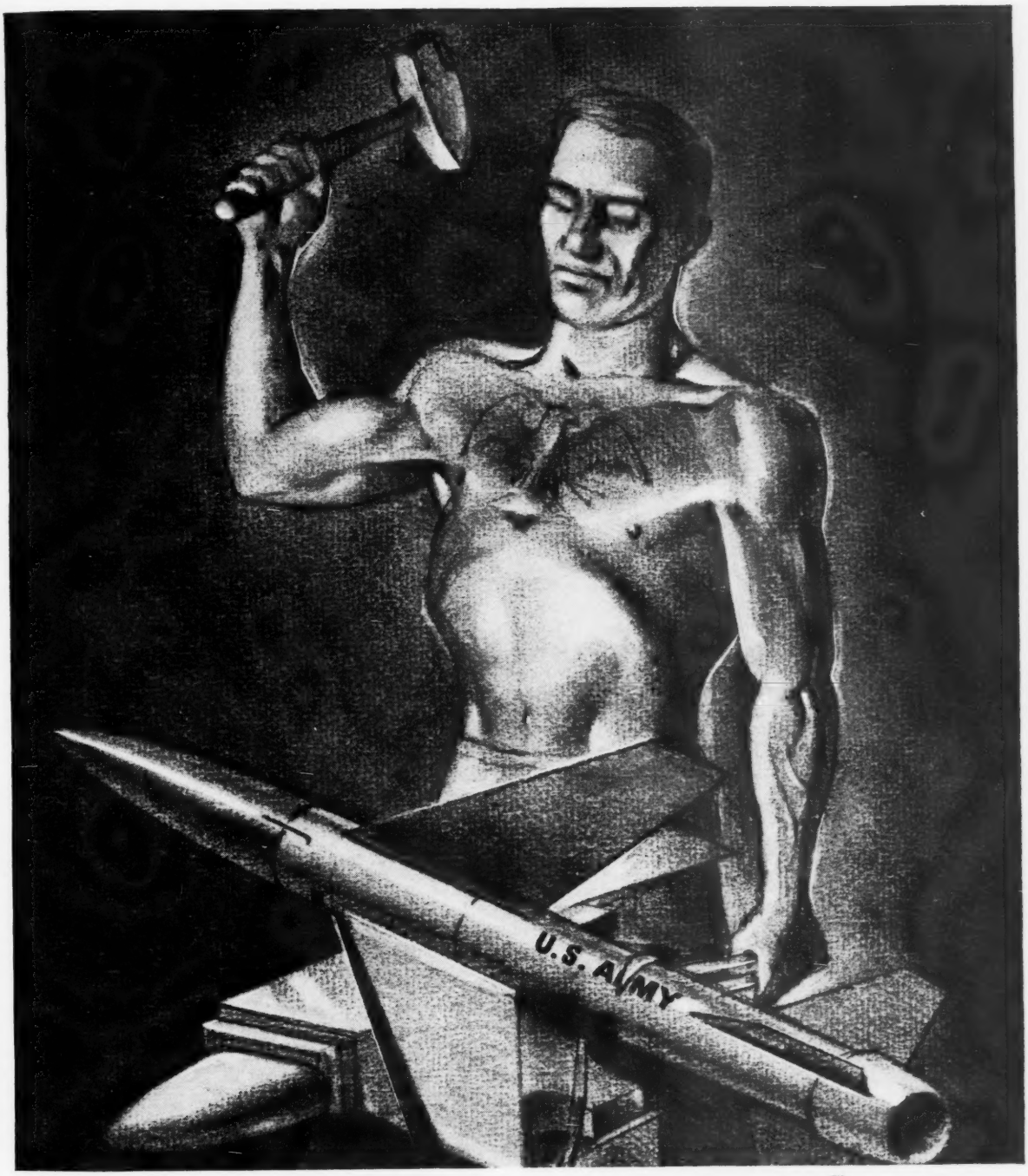

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This man-size instrumented dummy has been used by the Air Force to develop supersonic-flight escape systems. Twenty-five compact Yardney Silvercell batteries power the instruments.

Von Braun Tribute to Goddard

(CONTINUED FROM PAGE 36)

tudes.' On March 16, 1926, he launched the world's first successful liquid fueled rocket at Auburn, Mass. Three years later, one of his rockets transported an instrument package that housed a barometer, thermometer, and camera. With the understanding aid of Gen. Charles Lindbergh and the Guggenheim Foundation, he established a modest research facility at Mescalero Ranch in Roswell, and that historic association gives full validity to the selection of this site for the permanent record of his work.

"On April 19, 1932, he demonstrated an automatic gyroscopic control mechanism. On March 28, 1935, he flew the first gyro-controlled rocket and on May 31, that year, one of his rockets soared to an altitude of 7800 ft. In 1936, the Smithsonian published the last of his reports for that institution, a record of his success in liquid propellant rocket development. He was the first to employ vanes mounted in the stream of escaping gas for the purpose of steering the rocket. He patented the concept of the multistage rocket, the principle employed in all our space exploratory efforts to date. He formulated the mathematical theory of rocket propulsion and flight, and first proved mathematically that rocket propulsion will function in a vacuum. He invented the first smokeless powder rocket, and was the first to recover instrument containers from rockets by parachute technique.

"The AMERICAN ROCKET SOCIETY has long since recognized his courage in sticking to his beliefs in the face of skepticism and indifference, heartbreaking technical difficulties, and with meager resources. The Society has credited him with developing rocketry 'from a vague dream to one of the most significant branches of modern engineering.'

"In his life and work, Dr. Goddard was the embodiment of a truth which is frequently overlooked in our characteristic reliance upon team effort. Of course, Dr. Goddard, too, was supported by a competent team, and most of its members are here with us today. But for all the credit so richly deserved by this team, it is well to remember that many of the most significant advances in science and technology have not emanated from teams but from the singular efforts of dedicated and solitary individuals.

"The formula to any success in life is the exercise of individual ability, and the formula for outstanding achievement in science, industry, or the arts is singleminded devotion. This is the one quality which distinguishes the truly great man, like Dr. Goddard, from his fellow citizens. Since time immemorial, it has been the singleminded devotion of dedicated men which has provided the human race with immortal works of art, with great books, great teachings, and great discoveries.

"The late Thomas Alva Edison regularly locked himself in a laboratory for days on end. He, too, had that rare capability of singlemindedness which allowed him to put every other consideration out of mind and concentrate entirely upon the problem at hand.

Einstein Was Similar

"Albert Einstein had that same quality of genius. One day he stopped a lady on the street in Princeton, where he lived, and asked if she could tell him where he was. 'Your home is right across the street,' she replied. 'I did not notice that,' Einstein commented.

"Many of the world's leading thinkers and doers have been considered 'eccentric' by others' standards. The significant thing is that they did not care or that, caring, they nevertheless had the fortitude and the conviction to carry them on. In spite of all drawbacks and discouragements, they persisted in their chosen work, impelled by a secret fire which drove them on quite oblivious to the wishes or expectations of society. I suspect they would be labeled 'visionary dreamers' in these days. Let us not forget that it has been the 'visionary dreamers' who have accomplished more for the edification and benefit of mankind than any other contributor to civilization past and present.

"If, as a people, we ever lose the capacity to continue exploratory effort in science and technology, with or without social blessing, we shall have stifled our mental rebels. Yet it is the mental rebel, the incorrigible nonconformist, who pursues his convictions despite all mockery or indifference, who is God's most precious gift. Without men ready and capable of thinking bold, new thoughts, of challenging the accepted theorems, the progressive development of human society would grind to a halt.

"Fifty-two years ago, and not yet a doctor, Robert Goddard submitted an article suggesting that atomic energy would one day propel a rocket into interplanetary space. A magazine editor declined the paper with thanks and told him that 'the speculation is interesting, but the impossibility of ever doing it is so certain that it is not practically useful. You have written well and clearly but not helpfully to science as I see it.'

"Practicality—what wonders have you denied mankind!

"Perhaps there is the abiding lesson of Robert Goddard's life, the common insistence of the oh so practical men upon measuring his proposals in terms of concrete, measurable, immediate results, the failure to understand his penetrating visions, to accept his revolutionary concepts.

"The creed of the 'practical' should go something like this:

"What I cannot see cannot exist.

"What I cannot touch is not there.

"What I cannot hear I do not understand.

"What I cannot taste has no substance.

"What I cannot smell is odorless.

"What I cannot understand I do not believe.

"There is the urgent challenge of the time as we venture across the threshold of limitless space, a challenge fresh in our thoughts on this occasion as we pay tribute to the man who dared. We must open our vision to the unknown, we must expect the unpredictable, we must value knowledge for its own worth, and we must cease to measure the new in terms of its usefulness alone.

"Dr. Goddard's contributions have provided a solid basis for the progressive development of rocketry as the means by which to achieve his shining ambition—the exploration of the space regions where the silent planets, stars, and galaxies await the adventurers who follow in his giant footsteps."

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for the conquest of space

WHAT KIND OF ENGINE FOR A SPACE-JEEP?

It takes a unique engine to jockey a space-jeep in for a landing on an orbiting space station—one that will give a space pilot instant control and precise maneuverability.

Such an engine is the fully controllable rocket engine—ideal for space travel yet as easy to operate as an automobile engine.

The rocket engines are ready now

Although the space-jeep is still a gleam in an engineer's eye, the controllable rocket engine is available now...and has immediate application for existing aircraft. The pilot of a plane with auxiliary rocket power can switch it on for sudden, swift acceleration at high altitudes... the aircraft's air-breathing turbojets supplying power for ordinary flight operations. This is the mixed-power theory. Since World War II several mixed-power concepts have been developed in foreign countries, including Russia, France and England.

Extra power for today's aircraft

Rocketdyne already has designed, tested, and manufactured rocket engines for mixed power applications. The AR-1 rocket engine is a liquid-propellant system, as are the large power plants for the Atlas, Thor, Jupiter, and Redstone ballistic missiles. The AR-1 passed stringent flight tests as a supplementary power plant on modern jet aircraft. Substantial improvements over normal near-sonic speed and 50,000-foot altitude capabilities were demonstrated in more than 100 test flights.

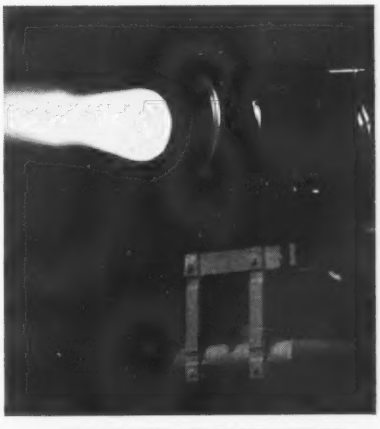
The AR-2, second in a series of four rocket-engine models developed by Rocketdyne, is a fully-throttleable engine that provides varied thrust. Using fuel from the airplane's tanks—which automatically ignites with hydrogen peroxide—these engines have full stop and restart capability.

More value for taxpayers' money

The auxiliary rocket engine gives present aircraft superperformance capabilities at a relatively low cost. It provides the increased speed and maneuverability that could spell the difference between the success or failure of an intercept mission. Almost any existing jet aircraft, as well as those now on the drawing board, can be adapted readily for AR engines.

Looking forward to tomorrow

Beyond a doubt, rocket power has a leading role in the Free World's future. Rocket-propelled airplanes, such as the X-15, will pave the way for man's entry into Outer Space. The multi-million-pound-thrust systems that are now under development at Rocketdyne will be man's means to explore interplanetary Space. But meanwhile, these rapid advances in rocketry can add great strength to America's present deterrent arsenal.



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The liquid-propellant AR rocket engines are "static tested" at Rocketdyne's field laboratory to measure thrust and performance.

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Behavior of Materials

(CONTINUED FROM PAGE 33)

hypothetical cable to both elevated temperature and high vacuum simultaneously, the end result will probably not be equal to the sum of the effects noted when each of the conditions is applied singly. Predicting the life expectancy of this one small component of a million dollar satellite is very difficult when we consider all the known aspects of the space environment.

Even though we know that there will certainly be cooperative phenomena whenever multiple conditions are imposed on a material, it is simplest to look first at the individual effects of the factors involved in space environment. A comprehensive research program should progress in its later stages to more complex (and expensive) multiple-variable experiments. In addition to determining effects on present materials, patterns may emerge in research data that will permit predicting the behavior of new materials in space applications.

The common denominator of space flight—the near vacuum of space—will affect materials detrimentally in many ways. In the simulation on earth of the other conditions existing in space, it is necessary first to create the high vacuum environment. Without it, meaningful results cannot be obtained in bombardment by charged particles, X-rays, micrometeorites, etc.

Effects of extremely low pressure encountered in space include the following:

Material Loss. Extremely low pressure can cause evaporation of volatile constituents (magnesium, zinc, hydrogen, plasticizers, etc.), with subsequent changes in the bulk strength of a material. This change in strength could be critical in structural members.

Surface Effects. The properties of surfaces represent an area of physics, chemistry, and metallurgy about which relatively little is known. Many of the most important phenomena associated with the behavior of materials are those occurring at surfaces or interfaces. Where surfaces or interfaces can be altered or removed by extremely low pressure, the resulting effects on the material must be considered in space vehicle design.

Mechanical properties of materials that rupture by progressive tearing can be affected by microscopic surface cracks and by intergranular corrosion. The presence of protective films or the lack of corroded and weakened surface layers may have appreciable influence on mechanical properties, particularly in situations where the surface is an area of highest stress.

Recent work in this field indicates that the effect of space on the formation of surface defects and the propagation of these defects (i.e., in notched specimens) may be more important than originally estimated. Work on the effect of vacuum on mechanical properties is currently being conducted at Massachusetts Institute of Technology.

Emissivity. Other properties of interest are the emission, absorption, and reflection of thermal radiation. Coefficients of emissivity and absorptivity are known to be influenced by the presence of a thin film of adsorbed gas and by the crystalline structure immediately adjacent to the surface. Emissivity will probably change when protective oxide layers are removed from metals. Such changes will be important in radiant heat transfer.

Loss of volatile materials may affect transmission of radiation, and particularly visible light, through a solid-to-gas interface. For example, surface films may well have dimensions comparable to the wavelength of the radiation concerned. From an optical viewpoint, the problem of matching impedances at the interface is not very difficult, but the absence of the atmosphere can have important effects on the surface films and optical characteristics.

Surface Conductivity. Closely related to the optical problem is the problem of electrical conduction along surfaces (surface leakage currents), since this property is also dependent upon surface films. High frequency electromagnetic signals are ordinarily propagated along the surface of a conductor (skin effect) and in the surrounding dielectric (vacuum). Conductivity of the surface layer is therefore important to low-loss propagation. In the isolated environment of outer space, significant amounts of electric charge can accumulate on the surfaces of certain dielectrics, and this may or may not be desirable.

Bulk Conductivity. In addition to the flow of electromagnetic energy along the surface of the material, the absence of an atmosphere may influence the flow of energy through material, described in terms of electrical and thermal conductivity. Electrical and thermal properties are ordinarily closely linked and cannot be readily specified independently. These properties may change slowly as a result of outgassing and loss of easily volatilized constituents upon long exposure to space.

Transmission. Another area of interest is the transmission of radiation through materials in a space vehicle. Many satellite vehicles require windows to provide vapor or gas barriers while permitting transmission of light, for both photographic purposes and physical measurements (lenses, prisms, etc.). A related problem is the transmission of high energy radiation, such as ultraviolet, X-rays, gamma rays, and even electrons or protons. High vacuum affects many plastics and may cause distortion of optical components.

Structural Integrity. A space vehicle presents problems of structural confinement since some areas of the vehicle must be maintained at pressures above the surrounding space. To assemble mechanical components or establish mechanical barriers in such a way that no leaks occur, a good deal of attention must be paid to welding, soldering, and brazing techniques for joining similar and dissimilar materials. A specialized area is that of seals, particularly those containing gaskets used for joints that are to be disassembled without destruction. Thermal expansion, cold flow, cold working, and cold-welding properties of materials must be considered. Significantly different cold-welding properties may occur which induce welding when it is not desired.

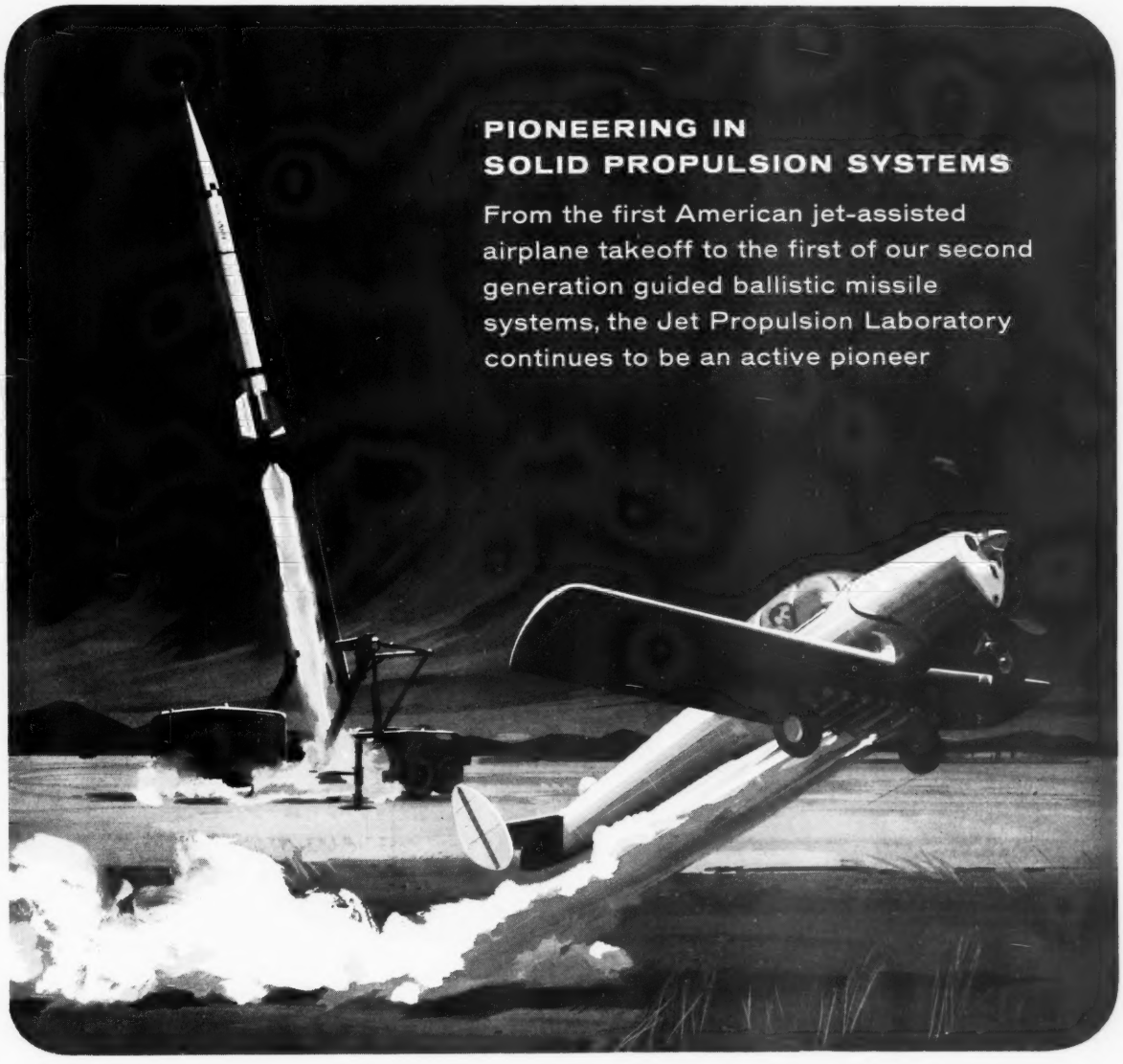
Vibrational Fatigue. Pressure in space is so low that no effective external viscous damping is present. Normal aircraft structural design (as well as stability and control) depends on the contribution of about 95 per cent of the total damping on structural skin

Characteristics of the Space Environment

(Natural and Induced)

- Low pressure and density
- Chemical composition and activity
- Thermal radiation fields, influencing temperature of vehicle
  - Infrared solar radiation
  - Earth's albedo
  - Re-radiation to 0 °K
- Other solar radiation
  - X-rays
  - Ultraviolet
  - Visible
- Cosmic radiation
  - Electromagnetic (X-rays, gammas)
  - Primary particles (protons, atomic nuclei)
  - Secondary particles (electrons, positrons, mesons, neutrons)
- Artificially produced radiation
  - Nuclear explosions
  - Nuclear propulsion
  - Other propulsion (ion, photon, etc.)
- Electromagnetic fields
  - Geomagnetic field
  - Interplanetary magnetic field
- Force fields
  - Gravity
  - Acceleration
  - Vibration
- Material fields
  - Micrometeorites at high velocity

NOTABLE ACHIEVEMENTS AT JPL...


PIONEERING IN
SOLID PROPULSION SYSTEMS
From the first American jet-assisted airplane takeoff to the first of our second generation guided ballistic missile systems, the Jet Propulsion Laboratory continues to be an active pioneer

In August 1941, America's first jet-assisted airplane takeoff was accomplished with an Ercoupe monoplane, using JPL developed solid propellant rockets. Scientists at JPL shortly discovered that a powdered perchlorate oxidizer, mixed with a liquefied plastic fuel binder, could be cast directly in plastic-lined light-weight motor cases. Thus a safe and cheap method was now available for preparing large internal-burning composite propellant charges. This basic process became the foundation for the modern solid propellant industry.

In 1954, U. S. Army Ordnance requested JPL to develop a compact, rugged long-range guided missile weapon system that could be transported, aimed and fired as simply as a cannon. Within five years, JPL perfected the **Sergeant,** the first of America's second-generation guided ballistic missiles. In January 1958, clusters of small-scale **Sergeants** helped launch America's first earth satellite, the JPL built **Explorer,** which provided vital space environment information.

Now under the direction of the National Aeronautics and Space Administration, the experienced JPL research and development team continues to apply solid propellant vehicles for space exploration.

jpl

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high-energy fuel briefs from Callery

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Lower-cost Diborane from Callery—Production quantities of Diborane are available from Callery at recently reduced prices. Investigations now under way on new process economies will mean even lower prices in the near future.

NASA awards contract to Callery for rocket propellant study—NASA has just announced the Government's first major contract award to Callery Chemical Company for research and development work in the field of rocket propellants. The NASA contract is to determine feasibility of a radically new propellant system.

New HiCal-3 fire-fighting film available for loan—This film shows the relative ease and safety with which a stable mechanical foam blanket can be established over burning HiCal liquid.

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R & D on fuels and propellants —Callery's credentials in this demanding field record over ten years of successful studies in fuels and propellants. A limited number of new projects can be handled by Callery now in the area of fuels and propellants, component testing, inorganic and organometallic chemistry. Your inquiry is invited.

Callery to open new office in Los Angeles—Sometime in June, fuel and propellant users in the Los Angeles area can contact Callery's Dr. R. G. Brault, Market Development Engineer, for helpful technical service. Dr. Brault formerly was coordinator of high-energy fuel projects in Callery's R & D program.

For information or loan of films, write to Defense Products Dept., Callery Chemical Company, 9600 Perry Highway, Pittsburgh 37, Pa.

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Dr. Robert G. Brault
Market Development Engineer
Defense Products Department
Callery Chemical Company

from the static or dynamic pressure of air. Less than 5 per cent is usually contributed by internal energy dissipation within the material. New design criteria may have to be adopted to avoid fatigue failure from induced and undamped structural vibration. This has not been critical, perhaps, with present operational satellites and ballistic missiles. Very large design safety factors have been inherent, relative to the forces normally expected in space, because the vehicles are designed to survive launching acceleration.

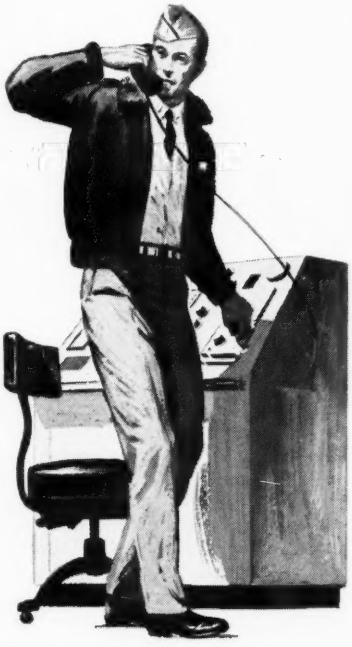
Friction. This will be a problem in space vehicle bearings and other sliding surfaces. Conventional lubricants are generally not feasible because of their high vapor pressures, although it is conceivable that a lubricant may be found which will be suitable for certain applications. Current knowledge of material characteristics in either sliding or rolling contact is probably of little relevance, since these phenomena are known to depend almost entirely on surface characteristics—characteristics which are strongly influenced by the presence of the atmosphere, either in providing a thin oxide film or an adsorbed gas film, or perhaps both. In addition to evaporation, problems may be encountered with foaming of lubricants as a result of evolution of dissolved gases or small fractions of volatile components.

Progress Made in England

Considerable progress has been made in England by F. P. Bowden of Cambridge Univ. studying changes of coefficients of friction as a function of pressure, temperature, and time. Under normal atmospheric conditions metals are protected by an oxide film and this in turn is covered with an adsorbed layer of gas or water vapor. When a surface is exposed to high vacuum, the amount of adsorbed gas on the surface lessens, and the coefficient of friction increases by as much as a factor of 2. With modest heating there is a further increase. When the surfaces are heated sufficiently to evaporate metal and oxide—and thus remove essentially all the protective layers—the coefficient of friction may rise to a value of more than 100 times the normal amount. Under such conditions sliding surfaces may bind or cold-weld.

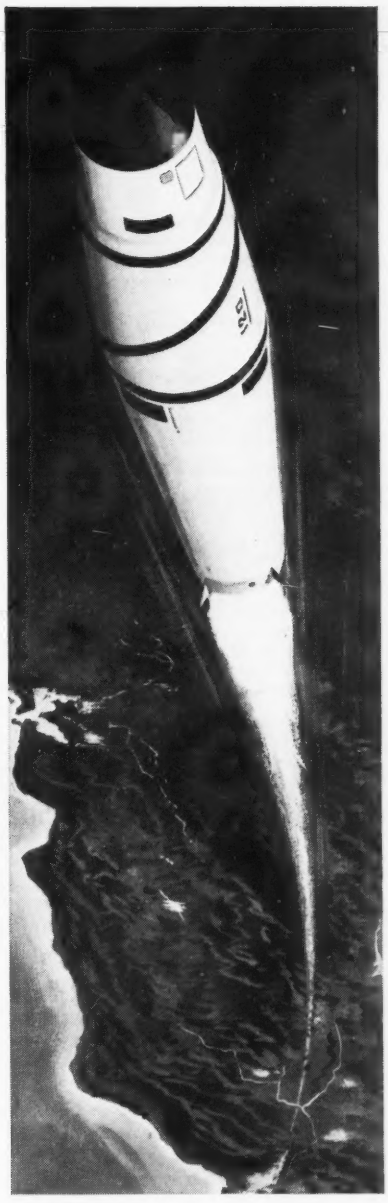
Less work has been done with nonmetals, but there appears to be a similar effect in this case. After removal of surface films, graphite exhibits an increase of five times its normal coefficient of friction, while sapphire and diamond increase by a factor of 10. In metal and nonmetals alike, surface wear increases even more rapidly than

SAC INTERMEDIATE RANGE BALLISTIC MISSILE



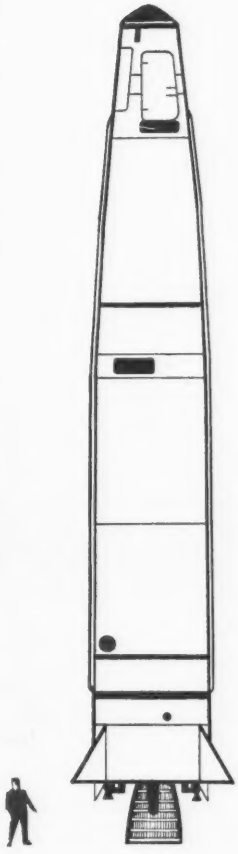
The man:

. . . a launch-control specialist in a *Thor* SAC squadron. His instruments report each automatic step in the launching procedure of the big IRBM. U.S. Air Force and Royal Air Force missilemen are receiving *Thor* training side-by-side . . . have readied and fired these missiles within a 20-minute count-down.



The missions:

. . . are many—because of the Douglas *Thor's* versatility. As a highly mobile weapon with atomic capability, it sternly warns potential enemies against aggression. As a powerful and reliable booster, it is playing a leading role in our exploration of outer space with satellites and probes.



The missile:

. . . can destroy targets as far as 1500 miles away within minutes after hostile action is detected. Douglas *Thor* missiles were the first intermediate range ballistic missiles to be deployed overseas. The United Kingdom has announced the delivery of the first *Thors*, for operation by Royal Air Force personnel.

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the coefficient of friction. In the case of graphite, for example, while the coefficient of friction increases by a factor of 5 the wear of graphite in vacuum is of the order of thousands of times that observed in air.

It is evident that friction will be a serious problem in mechanisms exposed to the very low pressure and other conditions encountered in space. While a few materials maintain low friction coefficients in vacuum (e.g., teflon and molybdenum disulfide), none of these are completely suitable for service in space vehicles. Considerable effort must be put into development of new antifriction materials for the full range of applications.

Preliminary evidence from Explorer satellites indicates that the temperatures encountered within the vehicle are quite nominal, in the range of perhaps −40 to 200 F. It is likely, however, that future vehicles, designed for other missions, will reach substantially higher or lower temperatures. A typical situation might be a component on the surface of a vehicle continuously pointed toward the sun, or continuously pointed away from it. Another possibility is a vehicle rotated in such a fashion that components are continuously exposed to radical temperature excursions.

With extreme temperatures, or wide temperature variations, the structural characteristics of materials can change. Such characteristics should be ascertained over a relatively wide range to ensure that strength is maintained and that embrittlement or solid-state phase changes do not adversely affect a material's performance.

Components involving mechanical motion, such as optical equipment, RF antennas, or navigational devices, require in some cases precise mechanical alignment. Materials used must maintain dimensional stability with freedom from distortion even when subjected to frequent thermal cycling.

Particle bombardment and radiation will also affect materials.

Control-Component Operation. In addition to possible catastrophic damage to the structure by micrometeoritic bombardment, there is a considerable problem involved if radiation penetrates into the power or control sections of the space vehicle. For example, the operation of most devices concerned with information processing, storage, and control depends on the solid-state properties of the materials of which they are composed. Transistors, solar batteries, magnetic cores, and thermoelectric power sources may fail completely if external radiation produces an unexpected source of electrons or ions within the material.

Abrasion. Material may be removed from (or possibly deposited on) the surface of a space vehicle by particle bombardment. Micrometeorites have sufficient energy to be a serious cause of abrasion and erosion, which can weaken structural members by reduction of volume. Less severe material loss may also cause surface defects that reduce effective bulk strength.

Sputtering. Bombardment may also occur by individual atomic particles, such as electrons, protons, alpha particles, and heavy ions. Many of these particles are expected to have sufficient energy to knock other atoms from a surface (the sputtering process). Mass removal rates are likely to be low, but the resulting surface defects may be as harmful as those from abrasion by micrometeorites.

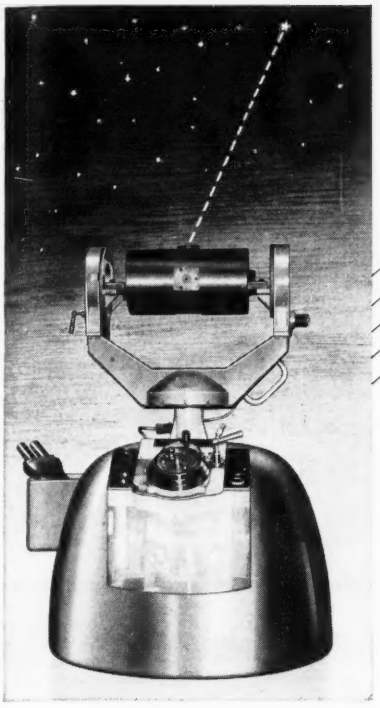
Abrasion and Sputtering

Abrasion and sputtering, in addition to affecting bulk structural properties, will have an even greater influence on certain surface properties already mentioned, such as friction, thermal emissivity. The abrasion of highly polished windows may quickly destroy the usefulness of an optical instrument. Changes in surface structure may alter the emissivity and absorptivity only slightly, and yet greatly influence heat balance, resulting in much higher temperatures within the equipment.

Mechanical misalignment may also be caused by radiation. One effect of radiation damage is very noticeable distortion of exposed materials.

High energy particles frequently cause dissociation and decomposition of normally stable molecules and thus create molecular fragments. High energy particle bombardment of atmospheric constituents will also produce ionized particles. These ionized particles, and the complex compounds formed from dissociation and subsequent recombination, may produce entirely unexpected results when in contact with the exterior surfaces of a vehicle. Moreover, low density gases such as hydrogen and helium may diffuse through material barriers.

In brief, the advent of space flight opens a new, and perhaps roguish, side to the character of a seemingly plain citizen of engineering, "properties of materials." Any extended venture into space may depend critically on the success of the research engineer in elucidating the behavior of materials under space-equivalent conditions in the laboratory, and eventually in space itself.



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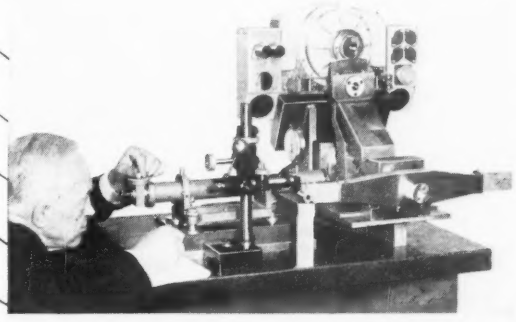

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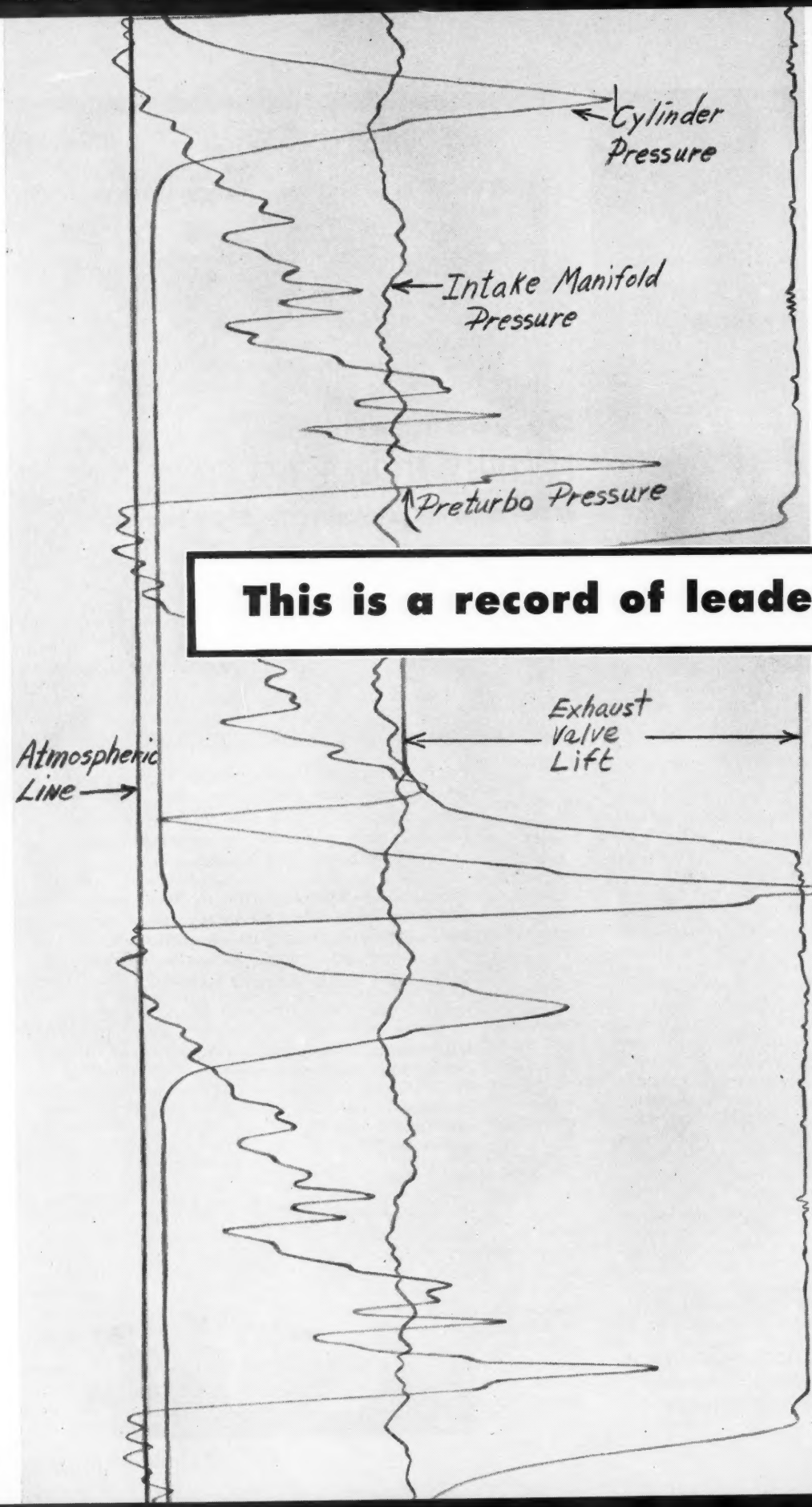

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The Worthington Corporation used a Honeywell 906 Visicorder to chart the heartbeat of a Worthington Tripower diesel engine. These Tripower (oil fuel, dual fuel, or spark ignition gas) engines have a fourteen inch bore, an eighteen inch stroke, and develop more than 265 h.p. per cylinder at 450 RPM.

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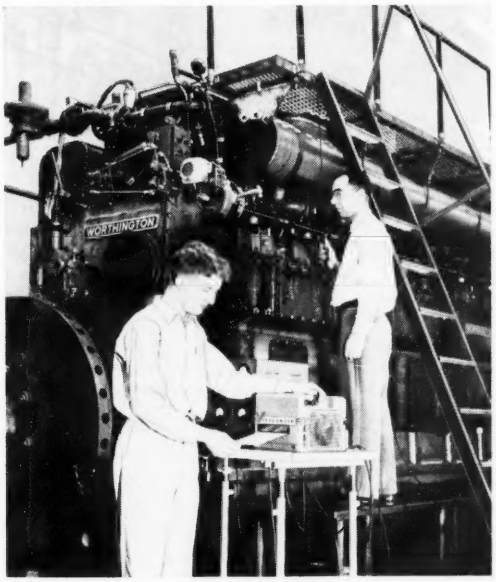
For the manifold and cylinder pressures, strain gauge pressure transducers and a strain gauge amplifier were used. For the valve lift patterns, a linear potentiometer powered with a small battery was connected directly to the Visicorder.

Analysis of these data has led to changes in the Tripower engine for best performance.

hipin diesel engine research



Ted Dupler (left) and John McAllister, Worthington Engine Research Engineers, measure intake manifold, cylinder, and exhaust manifold pressures and valve stroke on a Tripower with a Honeywell 906 Visicorder.

The Honeywell Visicorder is the pioneer and unquestioned leader in the field of high-frequency, high-sensitivity direct recording oscillography. In research, development and product testing everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

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Missile market

BY JEROME M. PUSTILNIK, Financial Editor

THE MISSILE Index was guided by electronics issues to a new all-time high in April, closing at 1128. The Dow-Jones Industrial Index also set a record high, but its 3.7 per cent rise was easily outdistanced as the Missile Index soared 13.2 per cent.

Divergent action within the index, however, demonstrates that investors must pick and choose with the same great care they would use in less dramatic markets. While Litton was up 29 per cent, Thiokol 24 per cent, and General Precision Equipment 8 per cent, Chance Vought was down 10 per cent and American Potash 13 per cent. Even a boiling stock market cannot produce profits for everybody, or for all security positions if they are selected indiscriminately. As Wall Street jargon would put it, selectivity was, and is, the keynote. Translating "selectivity" means choosing the right stock at the right time—which is much easier said than done. (In spite of this problem, it is interesting to note that in the four years since the index was set up, it has risen 3.5 times as much as the Dow-Jones, which increased 46 per cent.)

As this column has emphasized repeatedly, however, rapidly growing companies prominent in new but important technological areas will be rewarding investments for the long-term investor, regardless of the fluctuations in the general stock market. Speaking specifically, several important new metals currently afford just such opportunities. These refractory metals (with melting points above 3620 F) are tantalum, columbium, and molybdenum.

Tantalum seems to be the most interesting at this time. Its high melting point, impressive strength over a wide temperature range, ductility, and resistance to sudden thermal and mechanical shock, open a wide variety of rocket, missile, and space vehicle applications to this metal and its alloys. Gas turbine engines are another market. But it is in the electronics field that tantalum seems to have the most exciting growth potential. Here its qualities make it the most nearly perfect material for capacitors. Tantalum's efficiency, and virtually complete resistance to corrosion, promise its gains will probably parallel the growth of transistors, because they go hand-in-hand in electronic circuits. Proving that this has begun already are these figures: In 1953, 1 million tantalum capacitors were produced. This figure climbed to 2 million units in 1954, 6 million in 1956, and zoomed to an estimated 20 million last year. The industry predicts between 35–45 million will be produced this year.

Kawecki Chemical and Fansteel Metallurgical are two leading producers of tantalum metal. Because Fansteel is a large company with many other products contributing to its volume, Kawecki is this column's choice. Kawecki gives the investor the best undiluted exposure to the growth projected for the use of tantalum.

Specializing in many of the newer metals, Kawecki produces tantalum, selinium, titanium, tungsten, zirconium, boron, and their compounds. Extensive research work also has been done on columbium, hafnium, and lithium. The company supplies electronics firms with selinium, used in rectifiers; and the aluminum industry is a major customer for titanium and zirconium and other products of Kawecki's Master Alloy Div.

With an increase in defense requirements, particularly in missile and miniaturized communications systems programs, Kawecki's tantalum business is booming. Computer, telephone, and civilian aircraft applications have increased, too, particularly where extremely small size and reliability are important, in association with the soaring use of transistors. Now that adequate supplies of tantalum are available for nonmilitary use, civilian applications also are developing steadily.

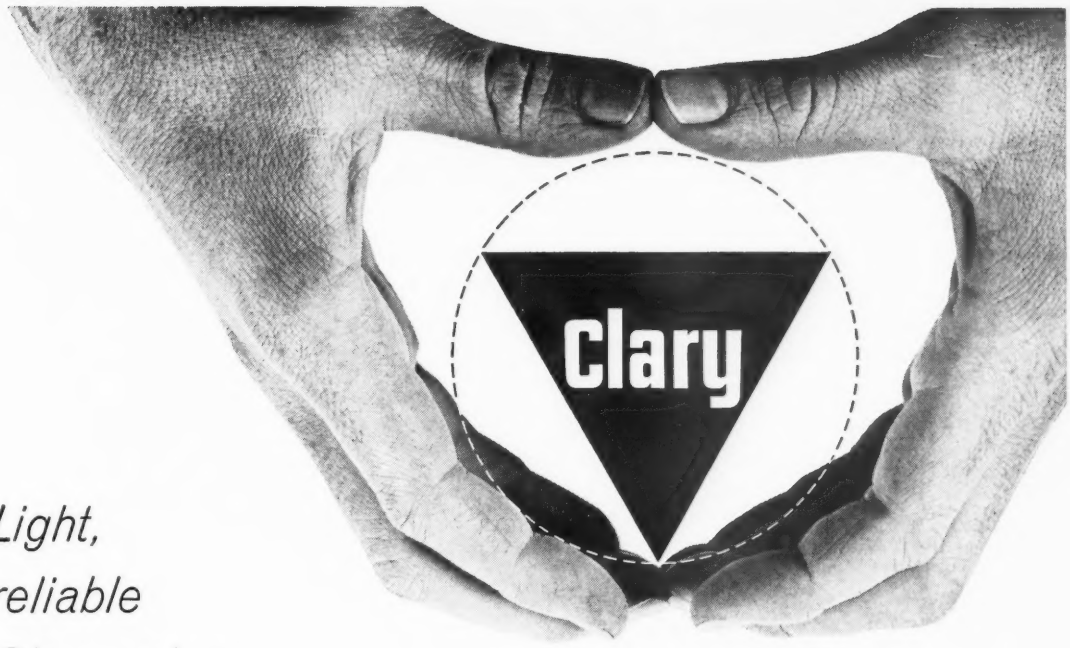
Responding to this demand, the company recently expanded and fully integrated its tantalum plant. Starting with the ore, which is processed through chemical purification, high purity tantalum chemicals or intermediates are produced. These are reduced to tantalum powder, and then consolidated and fabricated into sheet, bar, rod, wire, tubing, and foil forms. The new plant aids quality control and permits faster deliveries. An adequate inventory of tantalite ore, an imported raw material, has been built up. These ores, together with tantalum inventories, comprise the major

(CONTINUED ON PAGE 112)

THE MARKET AT A GLANCE

*Index compiled June, 1955

	May 1959	April 1959	% Change	May 1958	% Change
Dow-Jones Industrials	624	602	+3.7	455	+37.2
Missile Index	1128	997	+13.2	589	+91.9



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Seals: "O" rings compatible with media
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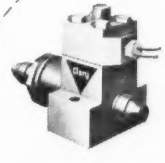

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ENGINEER or PHYSICIST. With experience in the use of scientific instruments for making physical measurement. Work related to flight test and facility instrumentation. Advanced degree desired with minimum of 3 years of related experience.

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Techniques for Recovery

(CONTINUED FROM PAGE 25)

ment of additional drag area, (3) by control of attitude to generate lift and induced drag, or (4) by a combination of these. The weight of the decelerator is extremely critical because of the cost of putting it into the initial satellite orbit and subsequent descent to re-entry position. Care must be taken to optimize the choice. The use of additional thrust impulses will generally be uneconomical during the principal part of the remainder of the trajectory. Ultimately, all of the vehicle's potential and kinetic energy must be dissipated through application of drag. The total distance over which the dissipation takes place may be extended by a factor of 3 to 5 by the use of lift and the effective drag area increase caused by the added induced drag that is developed. Effectiveness of the lift vector will also result in diminishing the peak acceleration experienced.

The re-entry process between 300,000 ft altitude and impact introduces two major problems: (1) A deceleration-versus-time profile that may be very damaging both to equipment and living passengers, and (2) the heating of the vehicle by the stagnation heat flux of the surrounding boundary layer. Both problems lead to most of the difficulties that are encountered in successfully bringing a re-entering body safely to earth. Decelerations greater than 60 g are possible during transit through the atmosphere, and this is way above the tolerance for a man. The temperatures of the boundary layer surrounding the body rise to, say, 10,000 or 20,000 F. Little wonder, then, that falling stars generally disintegrate before impact.

To hold deceleration to a tolerable value, it is desirable to produce as much drag as possible in the initial stages of re-entry, when the atmosphere is less dense, so as to attain the allowed tolerable deceleration ("n" level) as rapidly as possible. Then drag area must be reduced gradually, as the atmosphere becomes more dense, to hold the tolerable deceleration constant. As an alternative, aerodynamic lift may also be generated by tilting the re-entering body to give it a positive angle of attack. This will be most helpful in trajectories that are nearly horizontal, in which the lift will inhibit continued downward acceleration by opposing the gravitational force on the body. Also, a decrease of the velocity along the flight path of the vehicle will occur because of the induced drag that is developed by the lifting process.

Both the variable-drag method of controlling deceleration or the lift method are difficult to achieve. For best efficiency, amplication of drag area may need to be many times the original drag area of the basic body.

For example, a 1250-lb sphere 10 ft in diam, re-entering from an initial altitude of 300,000 ft and starting from circular orbital velocity of 25,600 fps, would require a maximum effective drag area of 3800 sq ft at 300,000 ft altitude and a minimum of 500 sq ft at 190,000 ft altitude to assure that its deceleration held at 4 g throughout this region. It would traverse 230 miles over the ground during 3 min of re-entry. Should the vehicle re-enter without benefit of drag augmentation, deceleration would approach 6.8 g.

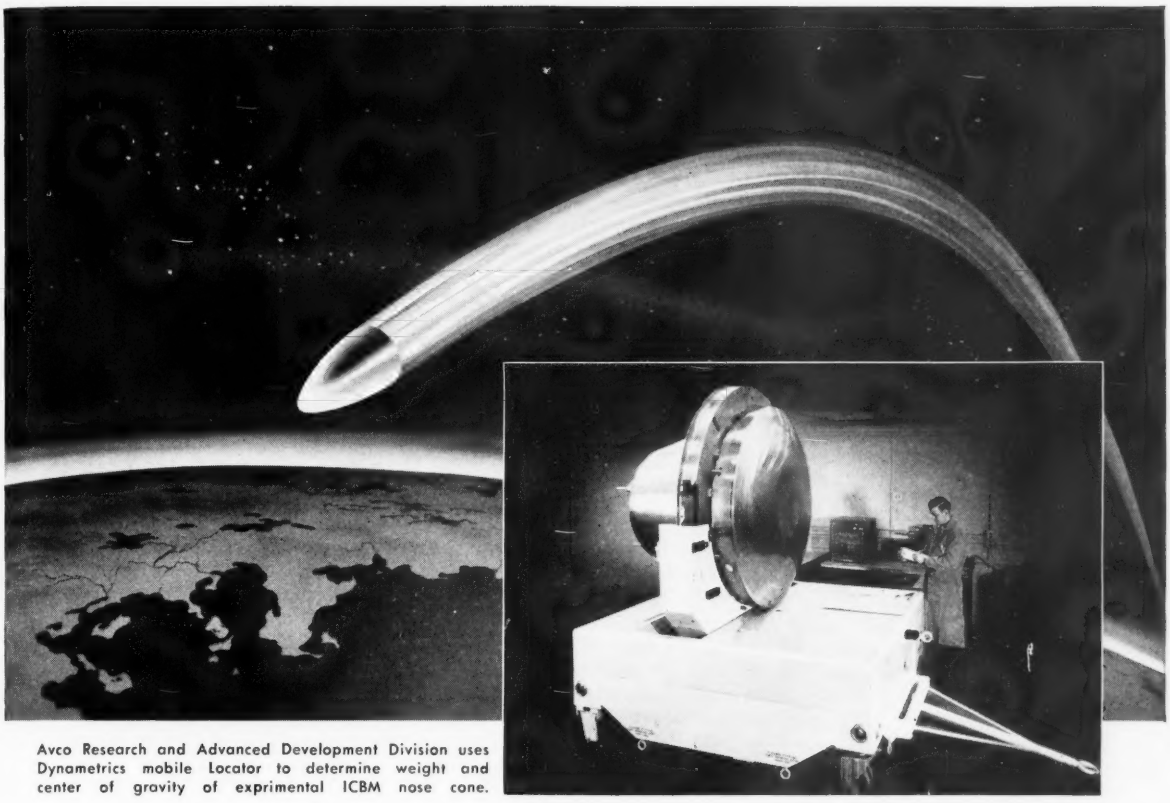
Thus, the addition of a parachute 100 to 125 ft in diam would reduce deceleration of this sphere from a very uncomfortable level to one which is more satisfactory. Of course, this parachute would have to operate hypersonically and be capable of performing its function at equlibrium temperatures approaching 2000 F. Parachute performance of this type must yet be demonstrated. It should be noted, however, that even without the parachute a tolerable condition exists for manned capsule re-entry—though certainly at the adventurer level of achievement.

Lift to Decrease Deceleration

Let us consider an example of lift to decrease deceleration. A re-entering body having a $C_D = 0.08$ and a $c_L = 0.40$ per radian angle of attack re-enters from 300,000 ft altitude from a horizontal trajectory when traveling 23,000 fps. If the body maintains a 12-deg angle of attack, it will arrive at the ground in 16 min, having traveled in the meantime 2600 miles over the ground. No deceleration in excess of 2 g would have been experienced. Lift of this type would not require wings, since sufficient lift can be obtained merely by inclining the body to the flight path. It will be noted that the range is 10 times that of the drag re-entry example, so that a much greater range error may exist.

In both instances, control systems would be required to maintain either the constant g-level by varying the drag area or to maintain the constant 12-deg angle of attack by CG control or control surface motion. In the latter case, roll control would also be required.

Parachute or drag-producing bodies of the type needed for the two described cases have not as yet been developed. Re-entry bodies capable



Avco Research and Advanced Development Division uses Dynametrics mobile Locator to determine weight and center of gravity of exprimental ICBM nose cone.

PUTTING THE BUSINESS END . . . IN BUSINESS

The nose cone or "business end" of an ICBM will disintegrate from the violent shock and 15,000°F temperature that builds up as it plunges back into the dense air surrounding the earth's surface, unless re-entry can be made at the optimum attitude.

Dynametrics has developed a Weight and Center of Gravity Locator for precise determination of weight of the nose cone and CG components along its 3 principal axes as part of the procedure for insuring that the nose cone will be aligned properly as it re-enters the atmosphere. Avco Research and Advanced Development Division, developers of re-entry vehicles for the Air Force Titan and Minuteman ICBM's, are successfully using a Dynametrics Locator to put the "business end" in business.

The Dynametrics Weight and Center of Gravity Locator combines the accuracy of a laboratory static balance indicator with the ruggedness required for field usage. At the flip of a switch, this unique instrument gives easily legible digital readout of weight and center of gravity for two axes of the nose cone. Then, by rotating the cone 90°, another reading is obtained in the same manner along the third axis. Measurements are independent of gravity variations since the instrument operates on the principle of gravity moment balance rather than spring deflection.

Capacity of the Locator is more than 4,000 lbs. with an indicator resolution of tenths of pounds. The Locator is mobile by air transport and is adaptable to quick field setup. This instrument can be used by untrained personnel — a most significant feature with reference to the operational phase of missile work.

The Weight and Center of Gravity Locator is a typical example of Dynametrics' capabilities in solving difficult force and pressure measurement problems. Write for technical information about any one of the Dynametrics' three areas of interest: *Special Services and Equipment* such as Wind Tunnel design, CG Locators, Strain Gage Balances, and Missile and Aircraft Models: *Weighing, Proportioning, and Batching Systems; Pressure Measuring Instruments* such as Manometers, Primary Presure Standards, Digital Barometers, etc.

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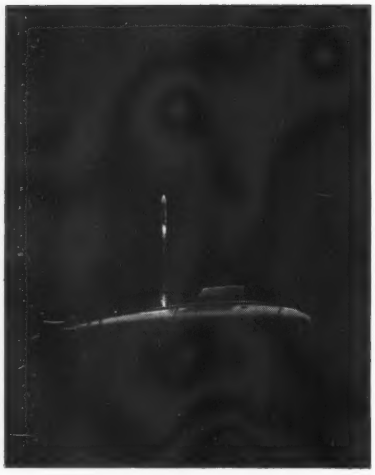

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of withstanding somewhat comparable heat and aerodynamic forces have been successfully recovered by the system developed by Cook Research Labs for the Jupiter-C and Jupiter nose cones. An artist's concept of a Jupiter-C type recovery process appears on page 24, along with an actual view of an early test drop. The entire Jupiter-C recovery system is compactly packaged, as shown on page 23. The principle re-entry drag was developed by the body itself, with only the terminal recovery portion of the trip supported by parachutes. Flotation was accomplished by means of a balloon. Because the trajectories used produced a much steeper trajectory than those discussed above, g levels were substantially higher. Vehicles with lift are yet to be tested.

Careful control of the re-entry angle at the initial 300,000-ft level is extremely important. Re-entry deceleration is appreciably increased for angles more than 2 or 3 deg below the horizontal.

The terminal phase of re-entry at ground impact for both the drag alone case and that with lift will require special treatment. Both might well use parachutes in the terminal phase to reduce the final velocity to perhaps 20 fps for light to moderately heavy bodies. Such a final velocity can be absorbed to a 3-g level by impact absorption bags having a useful compaction thickness of about 24 in. The decision to use impact absorbers, such as self-inflating or forcefully inflated airbags that dissipate the final kinetic energy by exhausting their air through a burst diaphragm, as compared to retro Jato's or rocket motors, must be based on over-all recovery system design. For example, recovery of an extremely heavy body would entail the use of so many large parachutes in clusters to achieve a low terminal velocity that retro Jato's would be much less complicated and more reliable. On the other hand, for light loads, impact bags are much simpler to handle.

The best recovery system for a given re-entry velocity and re-entry angle must be carefully developed through use of trajectory studies similar to those discussed above. In addition, the state of the art of these systems must be taken into consideration. Such programs as NASA's Project Mercury, which plans to recover a man from a satellite orbit, will use the pure drag type of recovery, with the drag of the capsule itself providing the primary deceleration, augmented by parachutes in the terminal phase. The pilot, or rather passenger, since he cannot do much to direct his flight, will be subjected to deceleration of about 10 g during flight—a very formidable value, but tolerable if he is lying prone on a well-padded "Beauty-Rest." Certainly this method is of the pioneering type.

The NASA X-15 project, and the more glorified Air Force Dynasoar program, are both based on the lift or airplane-like type of vehicle capable of being boosted into flight paths which tend to develop orbital characteristics to extend their normal glide capability. This type of vehicle requires some type of emergency escape capsule, probably of the drag-decelerated type, since the concept of an airplane within an airplane is too complex.

Parachute Research Data Used

Designers of recovery systems for these vehicles lean heavily upon Cook Research Labs' parachute research data and the many proved systems designed by Cook. We may cite the Skokie and Cree missiles, developed for WADC as transonic and supersonic parachute test vehicles. These were recovered by auxiliary parachutes after the test interval had passed. Photos on page 25 show a Nike-Cajun missile used by the Ballistic Research Lab of Aberdeen Proving Ground for the IGY program. This missile contains a two-stage recovery system developed by Cook for vertical trajectories to 72 miles altitude. The initial deceleration is accomplished by a pair of dive brakes extended at zenith followed by a recovery parachute released at 30,000 ft altitude. In all of these vehicles, terminal impact is taken by a nose spike that penetrates the ground to absorb the final kinetic energy.

Basic research in both the sled-borne and airborne areas are continuing under the guidance of the Parachute Branch of the Aeronautical Accessories Lab of WADC with augmentation through AF and NASA wind tunnels to extend existing information of these drag devices.

Acoustic, Vibration Test Equipment Available

Brush Instruments offers a discontinued line of Danish acoustic and vibration test equipment at reduced prices to educational and nonprofit research organizations. For more information, contact N. R. Klivans at Brush, 37th and Perkins, Cleveland 14, Ohio.

Martin Lacrosse Plays Deadly Game

Mobile as a chess queen, quick as a rapier thrust and as lethal as brass knuckles, the Martin Orlando Lacrosse is a handy weapon in a scrap. Developed, designed and built for the U. S. Army, the Lacrosse can flit like a ghost behind the battle area, fire in the general direction of the target and be pin-pointed by a forward guidance station.

The Lacrosse's ability to change its mind while in high velocity flight is another in the growing list of accomplishments by the men of Martin Orlando. Additional prime contracts include the Bullpup, air-to-surface missile, the Pershing, selective-range surface-to-surface missile and the Missile Master, electronic detection and control system for missile batteries.

Blue sky vision plus feet on the ground know-how has projected Martin Orlando to its place of leadership in electronics and missiles. Martin Orlando needs men with gray matter, the solid propellant needed to reach ever higher degrees of sophistication.

Immediate openings at senior level exist for Electronic Engineers, Physicists and Electrical Engineers in these areas: pulse circuitry, electronic packaging, transistor circuitry, electronic production test equipment, digital and analog computers. Also opportunities for men experienced in calculating solid state parameters, molecular distribution and quantum mechanics. Send confidential resume to: J. F. Wallace, Director of Professional Staffing, The Martin Company, Orlando 42, Florida.

MARTIN
ORLANDO

Ft. Sill, Okla., June, 1959—The first two U. S. Army Battalions employing highly accurate Lacrosse surface-to-surface missiles will be activated this month. Martin Orlando is supplying all the material required for the activation, including maintenance, training devices, launchers and missiles.

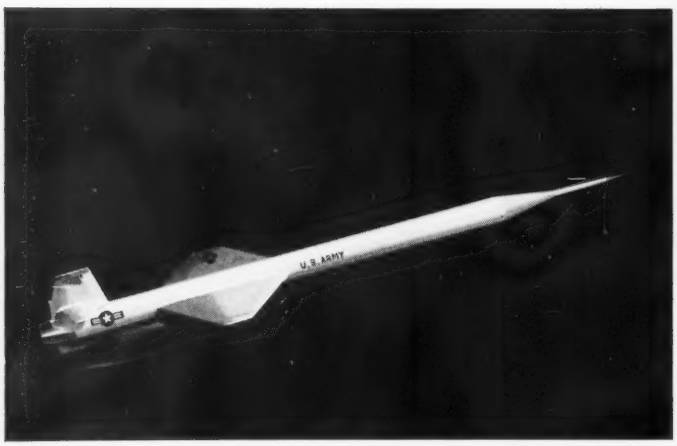
What Lockheed is doing today to develop
Tomorrow's missiles and spacecraft

The world's first polar-orbiting satellites...the world's fastest ramjet target drone...a "fuel cell" that produces auxiliary power for spacecraft in a radically different way...a TV camera-transmitter—the world's smallest—that gives engineers and scientists on the ground a televised report of what takes place in test missiles during flight. These are just a few of the many activities and achievements of Lockheed's Missiles and Space Division.

Lockheed is System Manager and Prime Contractor of the ARPA DISCOVERER satellite series—and the U. S. Navy's POLARIS missile. Both are highest priority programs of the U. S. Government. And both are ahead of schedule.

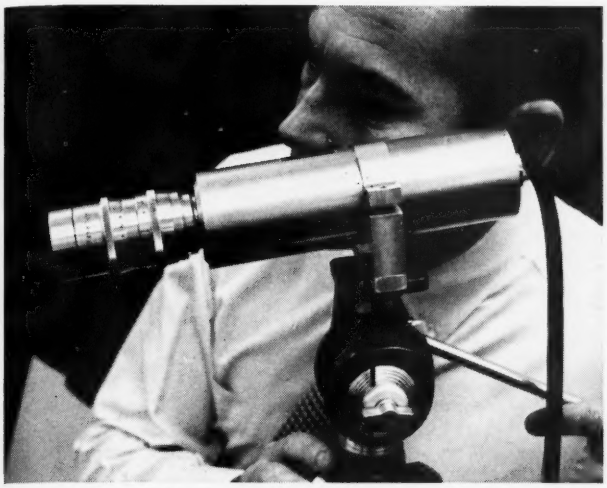
A Lockheed MSD work-force of over 16,000—including 3,500 scientists and engineers—is engaged in all phases of missile and space technology: satellite systems development; space communications; electronics; ionic, nuclear, and solar propulsion; magnetohydrodynamics; computer research and development; flight sciences; materials and processes; human engineering; electromagnetic wave propagation and radiation—and many other advanced fields.

From these efforts at Lockheed will come many significant breakthroughs and scientific "firsts"—to speed the development of tomorrow's missiles and spacecraft.



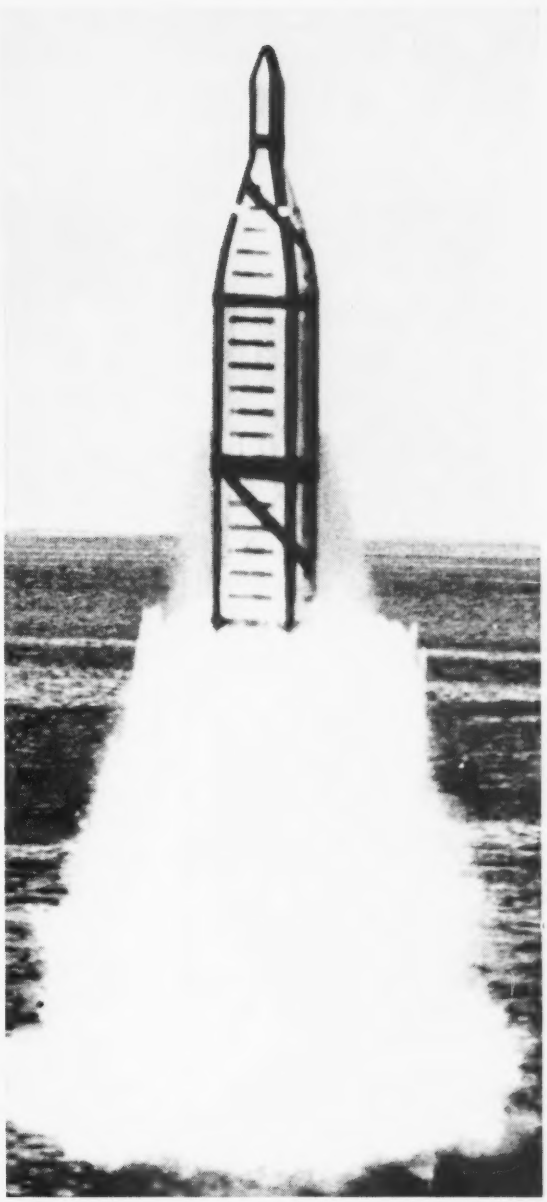
Ramjet-powered supersonic target, Lockheed Q-5 KINGFISHER electronically simulates enemy attackers—is being used by U. S. Army to evaluate and sharpen our nation's missile marksmanship, increase our defense capabilities.

First polar-orbiting satellites, the Lockheed-built DISCOVERER I and II were orbited in two successive launches. Lockheed is System Manager for this ARPA advanced scientific research program.



Transmitting performance data from missiles and test vehicles, direct to ground stations, Lockheed-developed TV camera-transmitter and PAM-FM telemetry systems are acknowledged to be the world's smallest, world's best.

Revolutionary "fuel cell," under development at Lockheed, converts chemical energy directly into electrical power—for auxiliary power requirements of miniaturized spacecraft instrumentation and space communications systems.



Erupting from beneath the sea, a full-scale POLARIS test vehicle demonstrates how operational missile will be launched from submerged U.S. Navy subs. Ultimate range of the POLARIS will be 1500 nautical miles.

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THERMO—DYNAMICISTS

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Please mail brief resume to C. L. Jones, Employment Mgr. or Telephone Gene Gregg, MU 34681 (Wichita). Proof of citizenship will be required.

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Wichita 1 **Kansas**

Hermann Oberth, from my life

(CONTINUED FROM PAGE 39)

means of giving a vehicle the velocity of 25,000 mph and lifting it out of the earth's gravity field.

At first I thought of a long tunnel lined inside with artificial ice. This tunnel was supposed to be nearly void of air and inside a powerful magnet was to run on skid runners. Round the tunnel was to be wound an electric coil in the fields of which the magnet was to be attracted in front and repulsed in the rear. Later, at the age of 14, I rejected this proposition, for I had calculated that the weight profile of the magnet would have to be at least 14 tons per square inch. Besides, for such a magnet, the tunnel was required to have a length of 10,000 km, since the acceleration then would be very small.

My next project was an airplane equipped with airscrews made of silk. Water trickling through the airscrews was supposed to cool them. This, if only for reasons of weight of coolant, was another failure!

Then I thought of a wheel, as sketched on page 39, with heavy weights (3) sliding to and fro and to on its spokes (2), the weights being guided by a fixed eccentric ring (4), so that they would be at a distance from the center on the one side and would come close to the center on the opposite side. In this way, I thought, a centrifugal force would develop on the side where the weights were at a greater distance from the axis, and lift the wheel.

I soon rejected this plan also, although I was not quite 14 years old and had not been told about a thing called "Force of Coriolis." I was nevertheless aware that in the points at (6) two forces, pushing exactly at the same amount downward as the excessive centrifugal force pulling upward, would appear, and that such a wheel never would rise. Every year I am approached by eight or ten inventors with what amounts to this scheme.

From the very beginning in these childhood projects, I always had in my mind the rockets designed by Jules Verne for braking the gravitational pull toward the moon and for changing direction of travel in space. I gradually realized that reaction propulsion actually offered the only means of achieving space travel and that giant rockets would be used as spaceships of the future, even if they lost in appearance any resemblance to our fireworks, as it is the case with the electric spaceship designed by myself.

I should tell a lie in stating that I was delighted at this discovery. I was not pleased at all with the enormous fuel consumption, the hazards of rockets containing solid fuels, the difficulty of handling liquid fuels, the high costs of the chemicals, etc.

I was not able to carry out any experimental work for a long time. It might well have been possible for me to produce and launch some rockets containing gunpowder. But such attempts appeared to me silly tricks compared to what I wanted to achieve.

There was, however, one thing I was able to do, and which offered me some satisfaction—inquire theoretically into the working principles underlying the operation of rockets, into the forces affecting their operation, and into the ways and means of producing improved and more efficient rockets.

At first, all this was nothing but a hobby for me, like catching butterflies or collecting stamps for other people, with the only difference that I was engaged in rocket development. In this way I had made headway into an entirely unknown province, never seriously approached by anybody before me. The fact that in 1919 Goddard in his paper "A Method of Reaching Extreme Altitudes" had expressly stated that no analytical formulas could be developed for establishing the most favorable rocket speed as well as the interdependence between fuel consumption and potential speed, among other remarks, revealed that I had carried on my investigations completely independent of Goddard's work.

Proof Published in 1923

A proof for this statement is my paper published in 1923 under the title "Die Rakete zu den Planetenräumen" ("The Rocket into the Interplanetary Space"), in which I set out by establishing the necessary formulas and then deriving therefrom everything I had to say about rocket development by using liquid fuels, the transportation of human passengers, indispensable preliminary investigations, etc.

When new ideas first come forward, standard science is always opposed to them in principle, particularly in Germany. Let me comment here on my schooling, which perhaps helped me to this opinion, as well as experiences in my later life.

Like most intelligent and lively boys, I hated going to school, especially since in our town there was only a high school, where such subjects as Latin and Greek were taught and, on top of it, the pupils received their education in a rather conservative spirit, not at all intended for the future. Our school compared to a motor car that,

W. P. Knight

Bill Knight is a rocket chemist. His field of interest is research on advanced solid and liquid propellants to meet the stringent requirements of today's military programs (and tomorrow's).

The continued success of the American missile program depends on men like Bill Knight.

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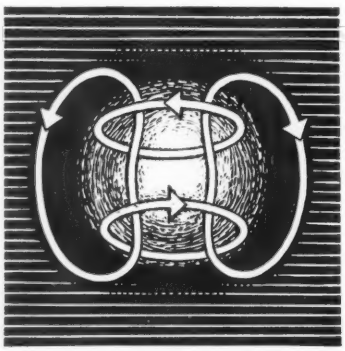

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This work involves basic research and development in the above areas primarily on existing contracts for defense against ballistic missiles.

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MISSILE SYSTEMS DIVISION
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in driving along a dark street, had directed its headlights backward and not forward. So, for instance, it happened still in the twelfth (last) grade that my German compositions were returned to me for recopying as a punishment. My writing was quite legible, except that I sometimes corrected my mistakes, considering I was not born to leave my mistakes uncorrected, once I had discovered them! All this happened in the years between 1900 and 1912, when any shopkeeper or lawyer of a certain standing and with a certain self-respect could already afford a typewriter. So any teacher who was then able to read the signs of the time would have realized that, later on, the youngsters in any walk of life would earn money enough also to afford a typewriter—at an expense that would have amounted to a fraction of those pains caused to them out of pedantry and backwardness, which perhaps was also mixed with a dash of cruelty.

Yet, our backward school system also did me something good. I became quite immune against the sayings of so-called authorities who were of a different opinion from my own. It was quite impossible that somebody could succeed with me in producing such arguments as, "Yet, the Privy Councilor so-and-so states that you are wrong" or "This is in contradiction to accepted scientific standards." But he who wanted to argue me out of my opinion, first had to prove that I was wrong. And this ability of mine would come in handy in the next 20 or 30 years!

[Ed.–Here, in a rather lengthy aside, Professor Oberth decries redundancy of research caused by poor intergroup communication, the lack of central abstracting agencies both here and abroad, and the imagination-sapping institutional pressure to get the paper out that keeps a scientist today "in the same position as a stuffed goose facing her food."]

In 1917, I submitted to the then German War Department a project for a long range missile with alcohol containing water and liquid air as propellants. It was to be controlled by rudders operated from a gyroscope through servomotors. The control of cutoff velocity was to be made by a weight pulling an elastic spring and thus generating through a potentiometer an electric current proportional to the acceleration. This current was to be conducted to an ammeter showing the speed, and triggering the closing of the propellant valves at the proper moment. This was the principle underlying the design of modern long range rocket-propelled missiles. In retrospect, we may say today that the lapse of time up to the end of the

war and the resources of the Central Powers, then already exhausted, would not have permitted such a development. All the same, my project deserved more attention than it received.

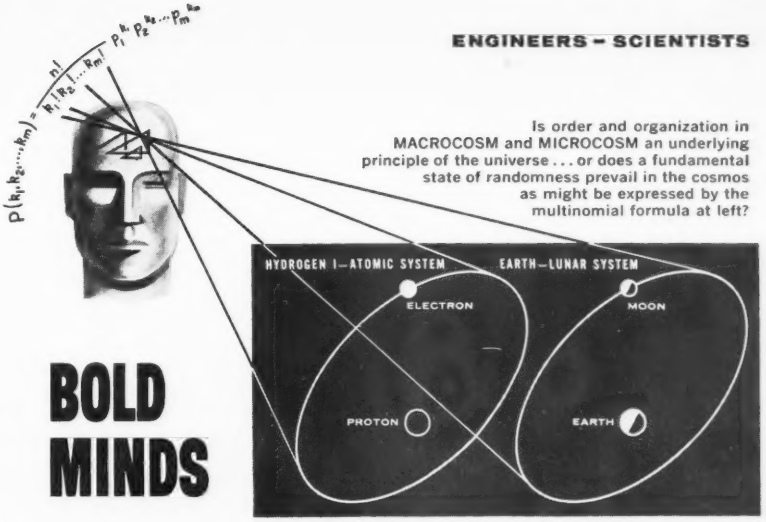
In my accompanying letter, based on my research work, I had stated the reasons why the rockets produced up to that date did not give better performance. In his answer, the competent official simply wrote that, "As known by experience, the rockets would not cover a distance greater than 3 km, nor was it to be expected that they would be substantially improved, considering the notorious Prussian accuracy they had been developed with." What he had done was to read just some passages in the introduction to my paper and did not think it worthwhile to consider whether my statement would prove true and take the lead in solving the rocket problem.

After World War I, I attempted to arouse the interest of German officials in my projects, but in vain. In 1922, I elaborated a paper on the results of my research work conducted up to that time. It was my aim, first, to set forth the theoretical principles underlying rocket development and then to demonstrate the feasibility of space travel. Moreover, I did not want any blame put on me that my ideas would be technically unfeasible. I gave, therefore, some suggestions as to how my plans could be realized, this not so much that I wished to make a point of it, but to demonstrate that there were any practical solutions to the problem at all.

Many Suggestions Adopted

In fact, I am rather surprised that so many of my former suggestions have been adopted in modern rocket development. Among others, only these should be mentioned: Regenerative cooling, reinforcing tanks by internal pressure, liquid fuels such as alcohol containing water and liquid oxygen, directional control by means of elastically suspended weights, speed control by generating an electric current proportional to the acceleration and flowing through an ammeter, cut-off velocity control by closing automatically the fuel valves when reaching the rated speed, and, finally, the use of liquid hydrogen as fuel in upper stages.

In 1922, I handed my paper to the Heidelberg Univ. as a thesis for my doctor's degree, but it was rejected. I refrained from writing another one, thinking to myself: Never mind, I will prove that I am able to become a greater scientist than some of you, even without the title of a doctor. (In the United States I am often addressed


ENGINEERS – SCIENTISTS
Is order and organization in MACROCOSM and MICROCOSM an underlying principle of the universe . . . or does a fundamental state of randomness prevail in the cosmos as might be expressed by the multinomial formula at left?
HYDROGEN I—ATOMIC SYSTEM
EARTH—LUNAR SYSTEM
ELECTRON
MOON
PROTON
EARTH
BOLD MINDS

THROUGHOUT HISTORY..... **BOLD MINDS** have sought to understand the forces at work in the universe, and as they developed working hypotheses, endeavored to turn all knowledge to their own purposes, devising philosophical and mechanical systems of their own.

As old hypotheses become inadequate or untenable, thinking men devise new ones. So the concept of a "flat" world has changed to an oblate orbiting spheroid—mere speck in a vast and expanding universe; so "empty" formless space is regarded as a curved continuum occupied by random knots of turbulence (creating the new branch of mechanics – hydromagnetics).

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as a doctor. I should like to point out, however, that I am not such and shall never think of becoming one.)

In 1923, I finally published my thesis paper under the title, "Die Rakete zu den Planetenräumen," thinking to myself that, in taking this roundabout byway of publicity, scientists might be induced to engage in this problem finally. Today, however, after having had the opportunity of looking closer into the university activities in Germany, I am no longer surprised about the fact that, even after years, none of them had properly read this publication.

In the meantime, however, such writers as Willy Ley, Max Valier, Otto Willy Gail, and Karl August von Laffert engaged in publications of a popular scientific character, carried my ideas into the limelight of public opinion.

In 1929, I was awarded for my second book, published under the title of "Wege zur Raumschiffahrt" ("Means for Space Travel"), the Rep-Hirsch Prize founded by Robert Esnault-Pelterie and André Hirsch. Then, also, the Opel rocket-propelled motor car made its appearance. So scientists were finally obliged to face the problem of rocketry.

In 1924, I moved to Wuerzburg in Germany at the invitation of a banker who wanted to finance my rocket project. However, it turned out that he was awaiting an opinion on the value of this project from a professor at the Berlin Technical Univ. Finally, after six months, the opinion arrived, by which time the money I had saved for experiments had been used for my support.

The professor wrote that my calculations were certainly correct, but, obviously, I had departed from sound fundamental premises. He advised the banker to abandon the project, but did not reveal how my fundamental premises were actually wrong. Nor did he so when I told him about my situation and called his attention in a courteous manner to his irresponsible procedure, since I was financially ruined by his action. Afterward, I was not able to carry on my research work for four years.

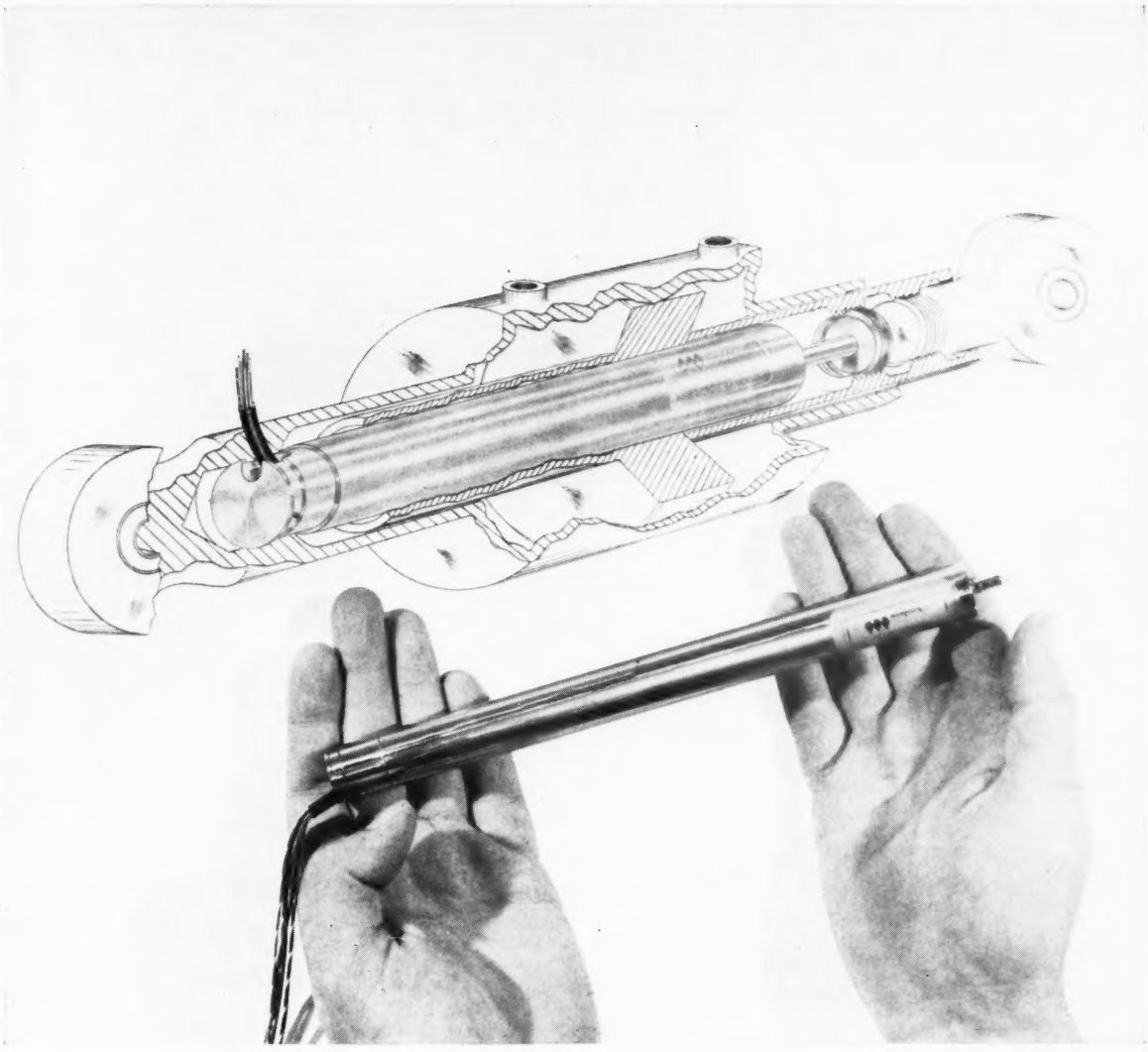
In the same year, Privy Councilor Prof. Dr.—a mathematician and authority in teaching mathematics—published a comment on my work in an educational review for mathematics and physics. It consisted in all of three sentences, running as follows: "We are inclined to give credit to the author stating that his rockets would reach cosmic speeds. All the same, it will not be possible to travel around in space because of the enormous wear of material. We think that the time has not yet come to deal with this problem, and probably it will never arrive!"

My retort to the effect that traveling in a rocket had nothing to do with coaching around in space, but rather compared to firing a shot, was not given publicity in that review, because at that time I did not know yet that I could have enforced its publication by virtue of the German Press Law.

Commented on Concepts

The concepts of rocket propulsion and its use in spaceflight continued to receive such worthy comment. In 1924, an astronomer and an engineer-chemist, both well known, expressed doubt that the power of reaction would be effective in vacuum, for there was nothing on what the exhaust gases could thrust. In 1925, the Professor of the Prussian War Academy and Director of the Prussian Rocket Agency, a major at that time, admitted that Newton's principle of reaction was correct. At the same time, however, he doubted that the power of reaction would be effective in vacuum. His first argument was that gases in the vacuum would get very thinned and therefore would lose mass. His second argument stated that it would be impossible to ignite gunpowder in the vacuum. In 1928, a professor, before the war a specialist in ballistics and afterward a professor ordinary, stated that the density of gases from gunpowder would be the lowest behind a rocket rising vertically into space, if the effective upward acceleration was 2 g and the relative acceleration 1 g. The fact that the integral, all the same, could assume a lower value than its integrand, if the limits were dependent on the integrand, and that it would decrease in proportion to the integrand increasing, the fellow had not grasped yet. Besides, he considered the launching of rockets in curved trajectories as pure nonsense, stating that the best solution to the problem would be offered by using thrusts effective always in the same direction. And the staging principle he had not grasped either, for he stated that two rockets would not rise higher than a single one of the same type. Based on his highly scientific calculations, he arrived at mass ratios amounting almost to the square of those actually required. These were almost the only arguments and opinions uttered by German university teachers in the years between 1923 and 1930.

I came to deeper realization that there are mistakes which are made only by people who have learned such a lot that they "cannot see the wood



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for the trees," as it was put once by Martin Luther.

In 1927, for the first time, I received from a German astronomer more credit. He wrote in a periodical that the statements contained in my paper stood his test wherever he was able to check them. He contested, however, my assertion to the effect that a telescope located in space would have a substantially greater range of visibility than a telescope located on the earth.

But to summarize some of my later activities. In June 1923, I passed an examination entitling me to teach mathematics and physics at Klausenburg, Transylvania. I obtained the title of "Professor Secundar," i.e., secondary schoolteacher. In 1923–24, I was a supplementary teacher at the Schässburg high school, and in 1924–38 a teacher at the Stefan Ludwig Roth School, a high school in Mediasch, Transylvania. During my years of studies in 1918–19, and later in 1929–30, I was granted leave to work for periods on rocketry, mostly in Berlin. There, among other activities, I acted as a scientific adviser for the film "Frau im Mond," produced by Fritz Lang. I also engaged in some experimental work with liquid fuels.

In 1938, I obtained another leave and was invited by the Vienna Technical High School to do some secret research work. (This was the preliminary work for the V-2.) In 1940, I received a similar commission from the Dresden Technical High School. In 1941, I became a German citizen and was commissioned on wartime duty to the German Army's Research and Experimental Center at Peenemünde. In 1943, I accepted an appointment to the W.A.S.A.G. (Westphälisch-Anahltische Sprengstoff–Aktiengesellshaft) and was assigned the task of developing a gunpowder rocket for anti-aircraft defense, for which I had submitted a suggestion. After the defeat of Germany, I was kept in custody by the Allies up to August 1945, and then released to my family living in Feucht, Germany, where I had bought a house in 1943.

From 1945 to 1948, I was a private teacher, a writer on scientific topics for *Mundus*, and occasionally a scientific adviser. In 1948, I went to Switzerland, living there initially by writing and advising. Later on, as a guest of the fireworks manufacturer, Hans Hamberger, I spent some time at Oberried on the Lake of Brienz, where I continued experiments I had formerly started when I was working for W.A.S.A.G. I then brought my research work, which I was able to continue in La Spezia from 1950 to 1953, commissioned there by the Italian Navy, to a certain conclusion.

In 1953, I returned to my home in Fuecht and lived there until 1955. Since March 1954, I am acknowledged as a former civil servant and entitled to an old-age pension. At the beginning of June 1955, I moved to Huntsville, Ala., where I worked at Redstone Arsenal on a secret project. In 1958, I joined ABMA, where I was in charge of a department commissioned mainly with the task of investigating what innovations might be anticipated in the field of rocket development in the next 10 years.

New Radiation Lab Underway

A laboratory for radiation damage experiments upon various materials and fuels, to be ready for operation in early 1960, will be built with Air Force funds at the Connecticut Aircraft Nuclear Engine Laboratory, Middletown, Conn. A Pratt & Whitney aircraft technical team which has been performing similar work at AEC's Livermore, Calif, facility will staff the new lab.

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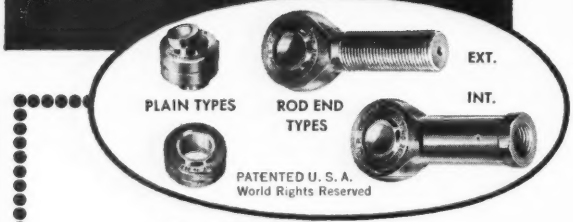

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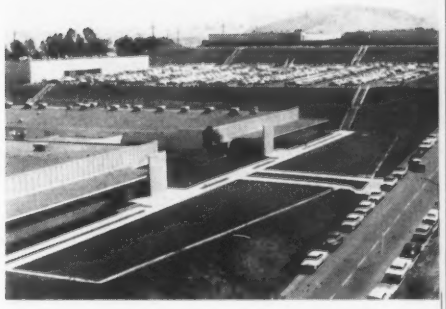
(above) Lockheed's "Hotshot" tunnel – only one in private industry.



(right) Research and Development facilities in the Stanford Industrial Park at Palo Alto, California, provide the latest in technical equipment.

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ARS on Amateur Rocketry

(CONTINUED FROM PAGE 35)

an amorphous binder of asphalt. However, this solution was made possible only after the organic chemist and physical chemist had contributed a basic knowledge of fuel structure and a wealth of chemical and physical properties; the chemical engineer had developed new techniques for manufacturing the propellant; the physicist and mathematician had provided a better understanding of the interior ballistics of the rocket; the mechanical engineer had supplied design criteria and structural features; and the metallurgist had found nozzle materials capable of withstanding the high flame temperatures encountered."

A footnote at this point makes the following observation, which in itself *should* dissuade lonewolf teenagers, or even small groups, from fooling with propellant concoctions:

"This group of specialists, in fact, constitutes the team that has been essential to the development of all new solid propellants or to the revision of existing propellants. Note that the alteration of a single propellant component or the mere introduction of a minor constituent can change the propellant completely."

Then comes the conclusion that (1) it would be impossible for the limited number of rocket experts in the U.S. to instill in each individual adolescent an understanding of rocketry so comprehensive that he could experiment safely on his own, and (2) while scientists and engineers have the best background on which to build rocket knowhow, they too must have extensive supplementary rocket training and experience before they are qualified to carry on or guide experimental work.

This conclusion, of course, explodes the position taken by many well-meaning individuals, and even responsible governmental agencies and organizations, that rocket experimentation should be encouraged "under competent supervision." The point is that science teachers are not competent to supervise rocket experiments which would have to be conducted using limited facilities and with the limited control that could be practically enforced upon amateur rocketeers.

Unfortunately, some individuals—even including some ARS members—have been actively encouraging experimentation under these vague and ambiguous rules which call for "proper supervision." Some have even written guide books which purport to be safety manuals and which even suggest design principles for the rockets. For example, the report states that amateur literature repeatedly calls for a nozzle throat diameter of one-third the rocket diameter, regardless of length. One wonders how an amateur could ever hope to control the dimensions of a rocket nozzle to a point where safe operation could be assured, when, as is dramatized in this report, the chamber pressure is so sensitive to slight changes in propellant burning area or nozzle throat size.

For example, states the report, "a rocket with an end-burning charge of Galcit propellant $^1/_2$ in. in diam by 5 in. long and designed for operation at a 1500-psi pressure would actually give a pressure of (a) 5100 psi if the throat diameter were merely 0.005-in. too small; (b) 17,400 psi if, alternately, the igniter blast opened an axial crack in the charge only $^1/_8$ in. deep; or alternately, (c) 180,000 psi (theoretically) if the igniter split the charge axially in half."

Naive Safety Instructions

Even more naive than the amateur guide book on instructions on rocket design are the instructions on safety. (There are exceptions. The Pacific Rocket Society and Reaction Research Society facilities and procedures are described and their safety precautions seem to be so thorough as to indicate that these organizations are outside the "amateur" category.) A number of these guides are listed and the report states that "all . . . are seriously deficient and dangerous in one major respect." This dangerous deficiency is, incidentally, noted in the lead paragraph of one of the booklets:

"It is impossible to give complete safety instructions for such a complex activity as rocket making and testing. Even if it were possible, the most elaborately detailed instructions would be useless if the rocket experimenter did not read them attentively and then keep safety—his own and the community's—uppermost in his mind."

Among the most jolting of the sections of the report is one which picks sentences out of descriptions of some of the teenager rocket experiments carried in newspapers and other sources:

"The rocket didn't go off so he hit it with a hatchet. Then it did!"

"He was just packing the fuel down with his hammer."

"After loading the rocket, he soldered on the fuse."

"He held it while a friend lit it."

"The loaded rocket was too long so he cut it in half with a hacksaw."

Most ARS Sections have shied away from involvement in the hair-raising projects of the amateur rocketeers, and many, notably the Florida, Maryland, Niagara Frontier, Alabama, Wichita and Colorado Sections, have educational programs which stick to the scientific principles of rocketry and spaceflight.

Such programs, the ARS Board of Directors concludes, are the only proper substitute for amateur rocket experimentation. The Society is, in fact, now compiling a book of nonhazardous experiments that relate to the scientific principles upon which spaceflight, rocketry, and their many allied sciences are based. All ARS Sections have already been contacted by John Newbauer, Associate Editor of ASTRONAUTICS, and invited to submit ideas for such experiments. All members of the Society are likewise invited to submit such ideas. It is hoped that the book will be ready for publication before the end of the year.

In the meantime, the Society feels a great responsibility to act as a medium of communication on the problem of amateur rocketry and as a stimulant to other organizations; to control the sources of propellant ingredients; to work with the National Safety Council, the National Fire Protection Assn., the Department of Defense, the Boy Scouts of America, the Science Clubs of America, and other organizations in communicating to schools and to the amateur rocket clubs themselves on the dangers that they are letting themselves in for.

ARS Sections are asked to contact the clubs that are listed in an appendix in the Amateur Rocketry Report, dissuade them from active experimentation, and provide instead lecturers and films from among their own members. ARS is sending copies of this report to all the agencies listed above and asking the cooperation of those agencies in reprinting and further distributing the report so that it will have maximum distribution in proper circles. It should be noted that the report lists methods of mixing propellants and sources of ingredients, and, as mentioned in the foreword by ARS President John P. Stapp, *must be kept out of the hands of the experimenters.*

Copies are being sent to each ARS Section president. Extra copies can be provided at $1.00 each (to cover costs) to responsible parties who request them, providing they give written promise not to pass them on to teenagers.

NRL Reports Available

A bibliography (PB 151428) of unclassified Naval Research Laboratory formal reports available to the public can be obtained for $2.75 from OTS, Dept. of Commerce, Washington 25, D.C.

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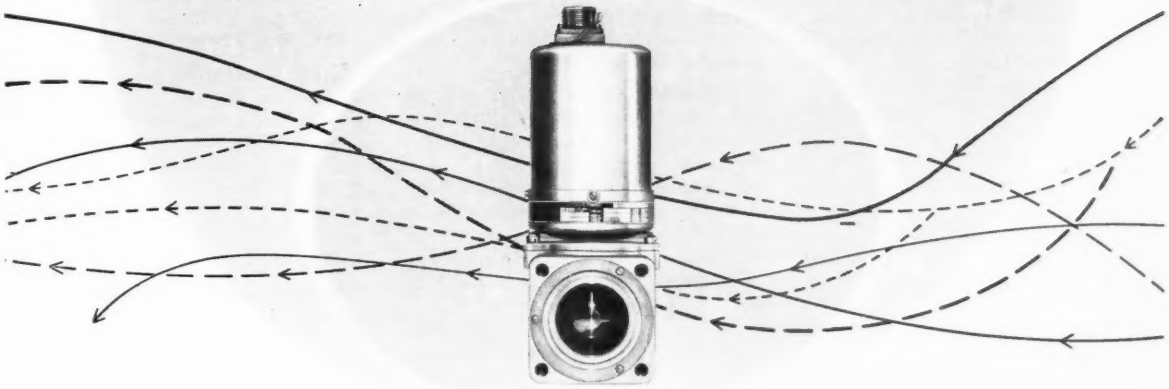

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Government contract awards

Project Mercury Environment System Job Goes to AiResearch

NASA selected Garrett Corp.'s AiResearch Mfg. Div. to supply the vital environmental control system for Project Mercury. The system will envelop the astronaut in an artificial environment of pure oxygen, and utilize a 28-hr supply of oxygen for breathing purposes and to cool and pressurize the capsule and astronaut's suit.

NASA Liquid Hydrogen Pact Awarded to Linde Co.

Linde Co. Div. of Union Carbide Corp. won a five-year NASA contract for West Coast purchases of liquid hydrogen with a low bid of $1.3 million, more than $1 million less than the next lowest bidder among four competing companies. No purchase amount is guaranteed. The plant, which will be an expansion of existing Linde facilities in Torrance, Calif., is to be in production by April 1960, with Linde underwriting the expansion costs.

ARGMA R&D Contract

Allied Chemical's General Chemical Div. will conduct a one-year research project on high energy oxidizers for advanced solid rocket propellants under terms of a $750,000 contract by the Army Rocket and Guided Missile Agency.

New ASW Concept

A new concept of underwater detection is being investigated by the Astrionics Div. of Fairchild Engine and Airplane Corp. under a contract awarded by ONR.

Missile Detection Study

Sylvania Electronics Systems has announced receipt of a missile detection study contract from the Air Development Center, Rome, N.Y., for various methods of classifying and tracking targets detected in an ICBM "defensive environment."

Grumman Gets $101.7 Million Award for New Jet Plane

A $101,701,000 development and production contract for a new Navy jet attack plane, the A2F-1, has been awarded Grumman Aircraft under a newly instituted Navy "cost-plus-incentive-fee" system which increases or decreases the contractor's profit on a basis of the aircraft's actual over-all performance, as well as on the contractor's control of costs.

Atlas Launcher Units

Waste King Corp.'s Technical Products Div. has received $180,000 in contracts from Convair-Astronautics for development and manufacture of a hydraulic temperature compensator in the hydraulic system which guides the Atlas and a rotating joint assembly for large air ducts in delivering low pressure air to the missile for both heating and cooling purposes.

Atlas Mobile Test Trailers

A $500,000 contract for modification of special mobile test trailers for the Atlas missile program has been let to Hallamore Electronics Div. by Convair.

Bomarc Gear

An Air Force production contract for $3,817,183 has been awarded to Motorola for 168 radar guidance beacons and command data links for Bomarc.

Missile Memory System

National Cash Register Co. Electronics Div. has received a $200,000, 14-month, prime design-development award from Navy BuOrd calling for the creation of an advanced magnetic-core memory system to be used in connection with missile weapons systems on ASW destroyers.

SAGE Support Equipment

The Air Force has awarded ITT Federal Div. an $11.4 million contract for missile and aircraft ground support equipment to be used in the Sage defense network.

"Hot Parts" Contracts

Ryan Aeronautical Co. has received $3 million in contracts for rocket motors, exhaust manifolds, and other "hot parts" for jet and piston-type engines from the Air Force, Firestone Tire and Rubber Co., and General Electric.

Rocket Motor Data

Consolidated Systems Corp. has received a $348,700 award from NASA's Jet Propulsion Lab for an automatic data-recording and monitoring system that will process data of rocket motor tests at Edwards AFB.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each

NASA CONTRACTS FOR MARCH

Contractor	Obligation	Program
U. S. Army Signal Corps	$ 540,000	Infrared and heat balance experiment in Project Tiros, a meteorological satellite.
General Electric	$4,120,000	Second stage, liquid propelled rocket engine to be mounted on an Atlas as Project Vega.
Jet Propulsion Lab	$3,000,000	Project Vega integration, payloads, and technical project supervision.
Bell Aircraft Corp.	$1,070,000	Feasibility of a high energy fluorine-liquid hydrogen rocket engine, including studies and hardware.
U. S. Army Ordnance and Cooper Development Co.	$ 20,000	Ten two-stage Nike-Asp sounding rockets to send 50-lb payloads to about 150 miles altitude.
Army Ordnance Missile Command	$ 100,000	To reimburse AOMC for special technical studies and activities.
U. S. Naval Ordnance Test Station	$ 100,000	R&D on advanced television cameras for space vehicles.
U. S. Weather Bureau	$ 150,000	Meteorological analysis in various experiments.
Naval Research Lab	$ 260,000	To buy test equipment for telemetry stations.
North American Aviation	$ 930,000	Project Mercury destruct system and design of ground transport vehicles and launcher.
Herrick L. Johnston, Inc.	$ 50,000	A 3600-gal liquid-hydrogen trailer in support of high energy rocket work at Lewis Research Center, Cleveland, Ohio.
Thiokol Chemical Corp.	$ 60,000	Recruit rocket motors in high energy work at Lewis Research Center.
Radioplane Div. of Northrop	$ 60,000	Landing and recovery system for Project Mercury capsule.
Electro Mechanical Research, Inc.	$ 120,000	For furnishing two telemetering systems to build a prototype for use in Project Mercury.
Cook Electric Co.	$ 80,000	Five 3-channel miniature airborne tape recorders for various projects.

Air Force, Army, and Navy contracting office:

AIR FORCE

AF Cambridge Research Center, ARDC, USAF, Laurence G. Hanscom Field, Bedford, Mass.

Determination of the orbital motion of Russian satellite, $54,177, **Republic Aviation,** Farmingdale, N.Y.

Research directed toward the study of the surface features of the moon and planets, $34,646, **New Mexico College of Agriculture and Mechanics Arts,** State College, N.M.

Research directed toward the collection, reduction, and evaluation of geomagnetic field data and electric field phenomena, atmospheric and terrestrial, $54,695, **Boston College,** Chestnut Hill, Mass.

Research on unipolar control devices, $70,000, **Radio Corp. of America,** RCA Laboratories, David Sarnoff Research Center, Princeton, N.J.

Research toward development, test, and fabrication of sun-azimuth pointing platform, $51,646, **General Electric Research Lab,** Schenectady, N.Y.

Design, development, and construction of swept frequency interferometer, $41,678, **Airborne Instruments Lab.,** Cutler-Hammer, Inc., 160 Old Country Rd., Mineola, N.Y.

Development of an electro-optical upper hemisphere scanning instrument for visible IR surveillance of the daylight sky, $111,132, **Electro Optical Systems, Inc.,** 170 N. Daisy Ave., Pasadena, Calif.

Research on computer device applications of thin magnetic films, $49,999, **Remington Rand Univac Div.,** Sperry Rand Corp., 19th St. and West Allegheny Ave., Philadelphia, Pa.

Study of informational capacity of antenna scanning systems, $38,288, **Itek Corp.,** 700 Commonwealth Ave., Boston, Mass.

Research on monocrystalline semiconductor films, $99,065, **Philco Corp.,** 4700 Wissahickon Ave., Philadelphia, Pa.

Design, construction, and testing of a photometric monitoring system, $28,794, **Optomechanisms, Inc.,** 216 E. Second St., Mineola, N.Y.

Research directed toward investigations of ferroelectric memory devices and systems, $49,950, **Horizons Inc.,** 2905 E. 79th St., Cleveland, Ohio.

Research toward development, test, and fabrication of sun-azimuth pointing platform, $40,018, **Ball Brothers Research Corp.,** Boulder, Colo.

Design and development of an airborne optical measurement system, $64,354, **Radio Corp. of America,** Defense Electronic Products, Burlington, Mass.

Fabrication of balloons and flight launch and recovery services, $30,523, **Raven Industries,** Sioux Falls, S. Dak.

AF Missile Development Center, ARDC, USAF, Holloman AFB, N.M.

Twenty-eight balloons, to be used by the Balloon Branch for experimental study, $35,949, **Winzen Research, Inc.,** 8401 Lyndale Ave., So., Minneapolis 20, Minn.

AF Missile Test Center, ARDC, USAF, Patrick AFB, Fla.

Increase in funds, $636,713, **Pan American World Airways,** 135 E. 42 St., Chrysler Bldg., New York 17, N.Y.

AF Office of Scientific Research, ARDC, Washington 25, D.C.

Continuation of research on orbital electron capture by nuclei, $50,000, **Western Reserve Univ., 10940 Euclid Ave., Cleveland, Ohio.**

Continuation of research on infrared study of free radicals, $25,975, **Univ. of Calif.,** Berkeley 4, Calif.

Continuation of study of projection of plasma, $25,000, **Stevens Institute of Technology,** Hoboken, N.J.

Continuation of research on ignition and burning of composite propellants, $40,000, **Univ. of Utah,** Salt Lake City, Utah.

Continuation of research on investigation of the high intensity arc for ion propulsion, $69,646, **Vitro Labs.,** Div. of Vitro Corp. of America, 200 Pleasant Valley Way, West Orange, N.J.

Continuation of research on ignition and combustion of organometallic compounds, $75,000, **New York Univ.,** New York, N.Y.

Continuation of research on paramagnetic resonance of free radicals, $75,000, **Washington Univ.,** St. Louis, Mo.

Research on electromagnetically induced chemical reaction, $63,982, **Republic Aviation,** Farmingdale, N.Y.

Research on theoretical and experimental studies of mass transfer for cooling, $116,994, **Univ. of Minnesota,** Minneapolis, Minn.

Continuation of research on acceleration and channeling of continuous plasma jets by magnetic fields, $82,354, **Plasmadyne Corp.,** 3839 S. Main St., Santa Ana, Calif.

Continuation of research on heat transfer characteristics diffusion boundary layers, $203,510, **MIT,** Cambridge, Mass.

Continuation of research on the influence of ions on rocket combustion processes, $54,024, **Reaction Motors Div.,** Thiokol Chemical Corp., Denville, N.J.

Directorate of Procurement, Air Proving Ground Center, ARDC, USAF, Eglin AFB, Fla.

Target, aerial, towed, infrared emitting, $73,189, **Delmar Engineering Labs,** Los Angeles 45, Calif.

Purchasing Office, Bureau of Aeronautics, Washington 25, D.C.

Design, tests, and furnish three models of an infrared free air thermometer system, $103,591, **Barnes Engineering.,** Stamford, Conn.

Sixty-six man months of engineering services to support the AAM-N-6, Sparrow II, guided missiles, and associated equipment, $106,639, **Raytheon Mfg. Co.,** Waltham 54, Mass.

Conduct a development program directed toward the improvement of ceramic coated molybdenum alloy components for jet engines, $38,100, **General Electric,** Cincinnati, Ohio.

Acquisition, rehabilitation, and installation of machine tools and other capital equipment necessary to support production of prepackaged liquid rocket engines, $979,090, **Thiokol Chemical Corp.,** Reaction Motors Div., Denville, N.J.

ARMY

Boston Ordnance Dist., Army Base, Boston 10, Mass.

Electronic assemblies, Hawk missile system, $719,907, **Raytheon Mfg. Co.,** Andover, Mass.

Research in re-entry physics, $984,000, **Avco Mfg. Corp.,** Everett, Mass.

Corps of Engineers, Office of the District Engineer, U.S. Army Engineer Dist., Tullahoma, Tenn.

Furnish a complete tunnel, arc chamber, and related steel structures for the Propulsion Wind Tunnel, Arnold Engineering Development Center, Tullahoma, $100,930, **McGregor-Michigan Corp.,** 13360 Helen Ave., Detroit 11, Mich.

Purchasing and Contracting Office, U.S. Army Engineer Research and Development Labs, Fort Belvoir, Va.

General research and development work in APPR-Type nuclear reactor systems, $180,024, **The Martin Co.,** Baltimore 3, Md.

Purchasing and Contracting Div., White Sands Missile Range, N.M.

Oscillograph recording systems, $62,116, **Sanborn Co.,** 175 Wyman St., Waltham, Mass.

U.S. Army Engineer Dist., Pittsburgh, Corps of Engineers, 925 New Federal Bldg., Pittsburgh 19, Pa.

Construction of missile master facilities, phase I and II, Pittsburgh Defense Area, Collier Township, Allegheny County, Pa., $2,715,237, **Malan Construction Corp.,** 2 Park Ave., New York 16, N.Y.

Construction of missile master facilities, phase I and II Pittsburgh Defense Area, Collier Township, Allegheny County, Pa., $2,715,237, **Malan Construction Corp.,** 2 Park Ave., New York 16, N.Y.

U.S. Army Ordnance Dist., Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Modification of guided missiles, $66,400, **Firestone Tire & Rubber Co.,** 2525 Firestone Blvd., Los Angeles 54, Calif.

Guided missile system, $10,911,000, **Firesone Tire & Rubber Co.,** Los Angeles, Calif.

Research and development, $107,455, **North American Aviation** Missile Div., Canoga Park, Calif.

High speed digital memory system, $394,074, **Telemeter Magnetics, Inc.,** Los Angeles, Calif.

Gyro units, $77, 853, **Waste King Corp.,** Technical Products Div., Los Angeles, Calif.

Research and development, $33,543, **Keystone Engineering Co.,** Los Angeles, Calif.

NAVY

District Public Works Office, Fourteenth Naval Dist., Navy No. 128,

FPO, San Francisco, Calif.
Guided missile support facility, U.S. Marine Corps Air Station, Kaneohe, Oahu, $22,990, **American Construction Co., Ltd.**, 2307 Date St., Honolulu, Hawaii.

Office of Naval Research, Washington 25, D.C.
Minitrack satellite tracking system, $172,121, **Technical Appliance Corp.**, Sherburne, N.Y.

Missile Market

(CONTINUED FROM PAGE 92)

portion of total inventories. R&D work is concentrated in developing extremely high purity chemicals and metals for the electronic and metallurgical industries.

Master Alloy Div. sales are surging, with 1958 showing a 90 per cent increase above the previous year. Expansion is the byword for this division, and a 30 per cent addition to plant capacity was completed last November. Capacity was increased again with another 50 per cent addition in May. The exceptionally high purity of the company's products makes them particularly useful in high strength, high temperature, electrical conductor alloy systems.

Kawecki's 1958 sales were $4.5 million, up 22 per cent over 1957. Most of this increase occurred in the second half of the year as the recession and cutbacks in military procurement hampered results for the first six months. Net income was $0.35 a share compared with $0.03 a share for the previous year. Management has reported that first quarter 1959 sales were ahead of the last quarter of 1958, and very substantially ahead of the first quarter of the previous year. This column believes Kawecki will enjoy major sales and earnings gains for full 1959 and again in 1960, and beyond. Earnings could be in the $1.25–1.50 a share range in 1959, and well above $2 a share next year.

Although the price of the stock does not look cheap on the basis of reported earnings, the company's potential (and growing awareness of tantalum's potential) indicates long-term investments should prove extremely rewarding. Traded on the American Stock Exchange, $1.5 million of long-term debt and 399,971 shares of common stock comprises Kawecki's capitalization.

Manufacturers of tantalum capacitors also afford some attractive opportunities for current investment. Sprague Electric and Pyramid Electric both seem interesting, and we hope to cover these companies at greater length in a future column.

Fellow Engineers and Scientists:

My company has asked me to tell you of the unusual opportunities in operations research at System Development Corporation. These range from positions for engineers and scientists who would like to develop their skills working in a team under an experienced leader to opportunities for those who are looking for positions of leadership. I hope that the following account of our work will lead you to inquire for further information.

Briefly, SDC's business is automated decision-making systems. More fully, we develop large scale, computer-based information processing systems in which the computer is used as an on-line, centralized control element for a system operating in real-time. At this stage of the art these systems are semi-automatic, the man-machine type in which man shares the repetitive control function with the computer. Our work is concept-oriented, rather than hardware-oriented, and deals with problems of over-all system design, data processing development, and man-machine system training.

The most fully developed large-scale semi-automatic system is the SAGE (Semi-Automatic Ground Environment) Air Defense System. We have a major responsibility in the development of SAGE. Our experience and unique team skills have led to diversification of our activities; we now have important contracts for other major military and government systems vital to our country. The demand for our services is reflected in our growth from 70 to more than 2,700 employees since 1955, and the intriguing possibilities of automated decision-making are only beginning to be realized.

In this brief message, I can only suggest the variety of operations research problems at SDC. Perhaps the most important point is that this variety is limited only by the imagination and initiative of our scientists.

Some examples of areas of work are: (1) allocation of decision-making functions between man and machine for optimal system performance; (2) measures of system capacity and system performance; (3) exploration and evaluation of design changes by operational gaming; (4) quality control and testing of operational computer programs; (5) allocation of computer capacity among several system functions; (6) scheduling and costing of production of operational computer programs; (7) optimal assignment of mixed weapons to targets.

SDC recognizes the importance of a well planned research program for the vitality and future of the company, and we are carefully organized to carry out such a program. The following are some areas our operations research people are involved in: (1) simulation and operational gaming techniques in problems of control systems; (2) information retrieval and theory of information processing; (3) medical data processing; (4) universal language for computer programming; (5) logistics. We have unusual facilities for research at SDC—these include one of the largest computer facilities in the world and outstanding simulation laboratories.

We have given considerable thought to organizing the activities at SDC to provide for professional development and self-expression. Operations research professionals are carefully assigned so that their individual talents are matched with company needs. These assignments are reviewed regularly to make sure that developing talents are directed into new company opportunities. We regard the publication of research articles and participation in professional societies as activities important to the company. We encourage new ideas and provide the time and means to explore them.

SDC is one of the leaders in a field which will have a remarkable technological and scientific development. It is a new and vigorous company with a bright future. I encourage you to join us.

Please write Mr. R. W. Frost at the address below if you wish to pursue this invitation.

William Lemuch

11-105A

SDC

William Karush
Assistant Director for Research
Operations and Management Research
System Development Corporation

SYSTEM DEVELOPMENT CORPORATION

2500 COLORADO AVENUE - SANTA MONICA, CALIFORNIA

New equipment and processes

Jet Engine Temperature Indicator: BH 183 temperature indicator reads within $^1/_2$ deg C over a range of 0–1200 C. It has a digital counter for fine reading. The case is 3 in. in diam and 7 in. long; unit weighs 1.75 lb. B & H Instrument Co., Inc., Ft. Worth, Tex.

Turbine Engine Analyzer: Analyzer provides information from 10 temperature and two vibration stations on each of four jet engines. Scintilla Div., Bendix Aviation Corp., Sidney, N.Y.

Thrustmeter: This device determines turbine engine thrust from measurements of the ratio of engine inlet and exhaust pressures. G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.

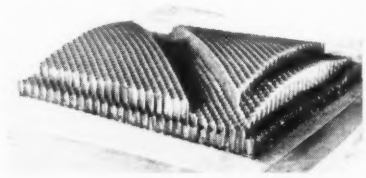
Missile Engine Ducts: A-286, a high temperature alloy in a low temperature duct, carries liquid oxygen from pump to thrust chamber in missiles. This lightweight corrosion- and temperature-resistant metal has high impact strength at low temperatures, and high strength-to-weight ratio at both high and low temperatures. Allegheny Ludlum Steel Corp., Pittsburgh 22, Pa.

Epoxy-Resin Optical Components: Both negative and positive casts of a special epoxy resin can now be made from precision-ground gloss master mirrors. Named the Repli-Kote mirror, the product duplicates intricate configurations with physical properties superior to glass. In shock resistance tests, epoxy samples have withstood an impact of 22,000 g. Mass-produced 6-in. paraboloid mirrors with a 5.25-in. focal length concentrate 90 per cent of incident collimated light within 0.1 mm diam. Reflective surface is an aluminum coating applied in high vacuum and overcoated with a protective film. Singer Military Products Div., New York, N.Y.

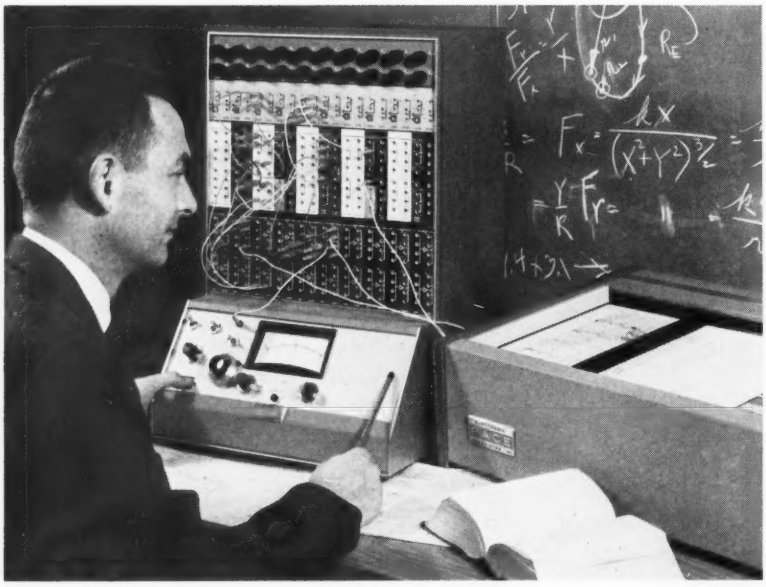
Recording Pyrometer: An optical recording pyrometer, called the Auto-Optic, measures extremely high temperatures with milliseconds response time. Developed to measure the high surface temperatures of sample materials, it can be operated unattended when conditions are hazardous to personnel. It accurately measures temperature changes over an area of $^3/_8$ in. diam in the range of 1400–3000 C. Avco Research and Advanced Development Div., Wilmington, Mass.

Flash X-Ray Equipment: New equipment by Zenith gives X-ray shadow pictures of hypervelocity ballistic bodies, high explosive fragmentation, and burning patterns of solid fuel propellants. Radiation lasts about one-sixth of a millionth of a second. The control system fits in a small cabinet. Zenith Radio Research Corp. of California, Redwood, Calif.

Machining of Honeycomb: Machining with an electrolytic process gives stainless-steel honeycomb most shapes, profiles, or contours that can be machined on solid metals. Close tolerances are held; no heat is generated to cause metallurgical changes; pieces are free of burrs and layover; and surfaces are stressfree. Ekstrom, Carlson & Co., 1400 Railroad Ave., Rockford, Ill.



Desk-Top, Transistorized Analog Computer Demonstrated by Electronic Associates



An engineer studies the solution of a static problem put to the Pace TR-10. Read-out equipment is one of several accessories that can be used with the computer.

A low cost analog computer which occupies little more desk top area than a standard electric typewriter and which can solve both linear and nonlinear problems has been introduced by Electronics Associates, Inc. Completely transistorized, the solid-state Pace TR-10 computer is 15″ by 17″ by 24″, weighs only 80 lb, and is priced at about $4000 for a basic unit up to about $8000 for complete unit plus X-Y variplotter. It performs addition and subtraction, multiplication and division, integration, and nonanalytical function generation to solve most of the routine mathematical operations encountered by an engineer in normal design calculations.

The basic unit can take added circuits to work out more complex computation. Desired parameter changes can be made after equations have been introduced into the unit with their effect noted on a plotter or oscilloscope. The unit has promise as an educational tool at colleges and universities and in industry for training engineers to use the larger analog computers, and take some of the load away from the big units.

ELECTRONIC LIFE PRESERVERS FOR THE MISSILE AGE

They're known as countermeasures.

To you, they could represent the difference between life and death.

Their job: to make missiles miss.

Active countermeasures may jam the radar which guides a missile. Or blind its electronic eyes. Or deflect it from its course. Or help seek it out and destroy it—miles from its target.

They Cannot Wait

If an attack ever comes, there are only minutes in which to act.

ITT is one of the companies holding the stop watch.

More than 15 years ago, in fact, the Department of Defense anticipated missile warfare and assigned ITT to countermeasure development.

Since then, many have been perfected. Others are now being tested. Still others are being rushed to completion. Some are active countermeasures. Others are passive countermeasures, which record hostile electronic activities.

Hundreds of ITT scientists and technicians, specialists in fields such as physics, astronautics, electronics, chemistry and metallurgy, are devoting their energies to the job.

At their disposal are the facilities of 101 growing research and manufacturing plants.

Many Other Big Jobs

Countermeasure development is one of the many areas in which ITT is engaged for the defense of the United States.

Guiding, controlling and testing missiles—to defend, to retaliate—is another vital area of activity.

Still another is the creation of a split-second global communications system for the Strategic Air Command.

And the development of earth satellites another.

The all-important job of operating and maintaining the DEW Line, our Distant Early Warning radar network in the Arctic, is also an ITT assignment.

Countermeasures Come First

The potentiality of missile warfare is a fact we must face squarely, realistically and *quickly*. Countermeasures must be on call. ITT will help to get them there in time.

See ITT Exhibit
WESTERN NATIONAL
ASTRONAUTICAL EXPOSITION
San Diego, June 9, 10, 11
Booth 18, 20, 21

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Miniature Pressure Switch: Model 3486 switch is for use with both hydraulic fluids and gases in 400–3000 psi systems. Its snap action is resistant to acceleration, shock, and vibration. Proof pressure, 4500 psi; burst pressure, 7500 psi. Weight, $^3/_4$ oz. Frebank Co., 711 W. Broadway, Glendale 4, Calif.

Isolated Power Supply: Providing an output isolated from line voltage and line ground, the transistorized Model 21 IPS provides 0–20 v of 1 amp dc power. An output receptacle permits remote shielding of power cables. Dimensions: 7 x 9 x 14 in. Moeller Instrument Co., Electonics Div., 132nd St. and 89th Ave., Richmond Hill 18, New York, N.Y.

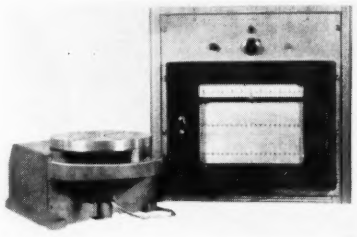
Gold Electroplating. Orosene 999 is a new gold complex that produces hard, ductile, mirrorbright 24-kt gold electroplates in either tank or barrel plating. The product contains no silver, antimony, or sulphur compounds. Control requires only one addition agent. Technic Inc., P.O. Box 965, Providence, R.I.

Sealing Glass: Code 9019 Multiform glass, made from minute particles pressed to shape and fired, can be hermetically fused to stainless steel in a low compression seal. Particles are consolidated by fusion into a nonporous vacuum tight structure. Corning Glass Works, Corning, N.Y.

Graphitized Textiles: Manufactured graphite (purity of 99.9 per cent) is now being produced in flexible fiber and fabric form. The fabric is graphitized by electrically heating to 5400 F. National Carbon Co., Div. of Union Carbide Corp., 30 E. 42 St., New York 16, N.Y.

Fiber Glass Tubing: Phenolite grade G-11-3680 or G-11-3681 (depending on diameter and wall thickness) comprises a rolled tube of glass fabric bonded with a heat resistant epoxy resin. Available in diameters from $^1/_8$–11-in. ID, and wall thicknesses from 0.010–5.5 in. National Vulcanized Fibre Co., 1059 Beech St., Wilmington 99, Del.

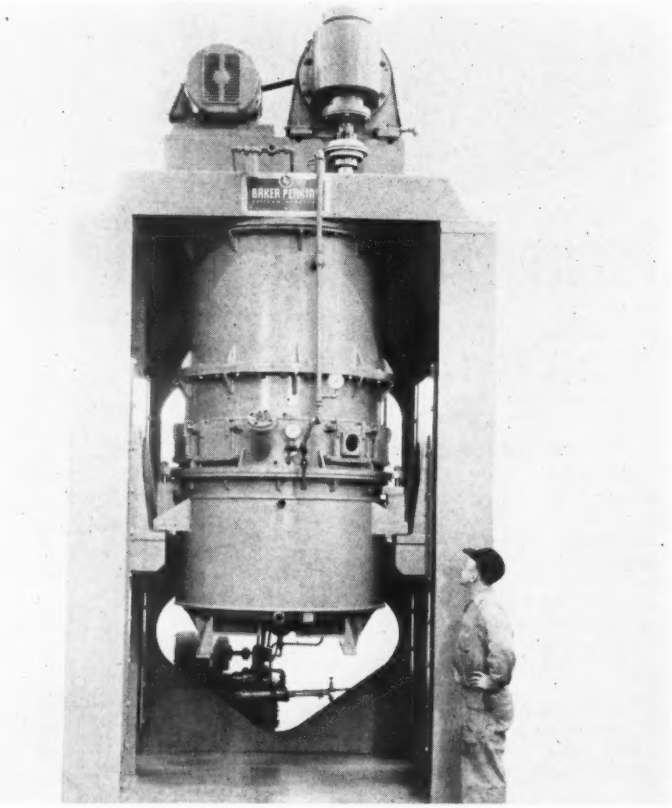
Test Turntable: Variable-rate test turntable Model 031 is used for evaluation and calibration of the response of gyroscopic and other inertial devices weighing up to 50 lb. Available in low speed and high speed models, it provides smooth stepless control and constant-speed platform performance, with regulation within 0.02 per cent of maximum range. J. W. Fecker, Inc., Subsidiary of American Optical Co., 6592 Hamilton Ave., Pittsburgh 6, Pa.



Thimble-Sized Tubes: The "Nuvistor" opens the way to mass production of high performance, thimble-sized electron tubes having ruggedness, reliability, and efficiency. Small signal triodes and tetrodes will be offered to the industry, followed by a beampower tube. Limited commercial production of the tubes is planned for 1960. Radio Corp. of America, 30 Rockefeller Plaza, New York 20, N.Y.

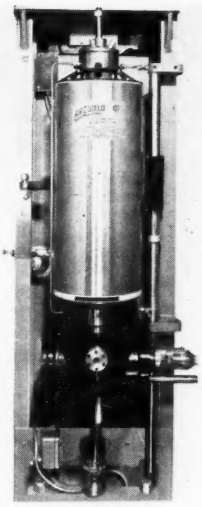
Silicon Cartridges: High voltage silicon cartridges, designed to replace Type 866 mercury vapor rectifier tubes, provide $^2/_3$ reduction in space, and weigh less than $^1/_{16}$ of the equivalent tube circuitry. Rated at 6400 PIV, the new units provide dc output currents of 250 ma at 75 C ambient temperature. Units measure 5 in. long, by $2^3/_8$ in. in diam. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

Space Environment Chamber: A chamber 8 ft in diam and 15 ft long has been developed to simulate environmental conditions up to 100-miles altitude. The system is trackmounted to provide accessibility and convenience in test preparation of large components and assemblies. Pumping equipment capacity is sufficient to handle considerable quantities of gas. Scientific Engineering Laboratories, 1510 Sixth St., Berkeley 10, Calif.



Planetary Mixers

Heavy duty vertical planetary mixers designed primarily for solid propellants are also suitable for mixing products that are abrasive, easily contaminated, or must be compounded in a vacuum. One unit, with a working capacity of 150 gal, can be used for internal pressure mixing with some design revisions. Chemical Machinery Div., Baker Perkins, Inc., 1000 Hess, Saginaw, Mich.



Vacuum Creep Retorts: Model RB-1800 is used with a vacuum retort furnace for temperatures up to 1800 F. It is built integral with a Kanthal-wound furnace, and has water-cooled windows for optical creep measuring. The 10 in. diam furnace is 16 in. long. Model RD-2600 is for use with a 21 in. long, platinum-wound furnace for temperatures up to 2600 F. Arcweld Mfg. Co., Grove City, Pa.

Microfilm Print Enlarger: The "Therm-Fox 29" microfilm reader-printer produces an 18- x 24-in. print from microfilm in less than 15 sec. The machine uses paper 18 in. wide capable of making 100 full size prints or 200 halfsize prints. It operates on regular 110 v ac. Minnesota Mining and Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

Visual-Audio Trainer: Training periods for intricate assembly work can be reduced by using the Learoaide which synchronizes a color slide projector with a tape recorder. Trainers set their own learning pace through any step-by-step assembly by controlling sequences with a stop-start-repeat feature. A speaker for group instruction is provided. Lear, Inc., P.O. Box 688, Grand Rapids, Mich.

Synthetic Elastomer: Designed for use with a variety of corrosive chemicals, synthetic fuels, and functional fluids, a highly fluorinated synthetic elastomer (Fluorel) resists oxidants such as 90 per cent H_2O_2, RFNA, silicate ester, JP-type fuels, HEH and HiCal fuels, etc. Chemical Div., Minnesota Mining and Mfg. Co., 900 Bush St., St. Paul 6, Minn.

Synthetic Rubber Hose: Constructed of "Viton," a new flexible hose can be used under conditions for which no previous hose of neutral or synthetic rubber or plastic was suitable. The hose can be used for short periods at 600 F, lasts long periods at 350 F, and resists extremes of chemical attack (e.g., aromatic fuels). E. I. du Pont de Nemours & Co., Wilmington, Del.

Film Magazine: Model M-3 Multidata film magazine holds 800 ft of 16-mm film for flight research cameras.

The magazine "throws" film to the camera on demand. Single frame shots or operation up to 40 frames per sec are possible for up to 16 times as long as with the standard 50-ft roll. Flight Research, Inc., Box 1F, Richmond, Va.

PRODUCT LITERATURE

Hi-Tensile Fastening. Elastic Stop Nut Corp. of America, Union, N.J.

Spectroscopes. Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.

Aircraft and missile equipment. Walter Kidde & Co., Inc., Aviation Div., Belleville 9, N.J.

Services available from WWV and WWVH. Specific Products, 21051 Costanso St., Box 425, Woodland Hills, Calif.

Gaseous oxygen laboratory tests critical missile equipment. Telecomputing Corp., 915 N. Citrus Ave., Los Angeles 38, Calif.

Plasmarc plating. Linde Co., Div. of Union Carbide Corp., 30 E. 42 St., New York 17, N.Y.

Arnav weight handbook. Arnav Aircraft Associates, Inc., 32 Industrial Ave., Little Ferry, N.J.

Antenna handbook. I-T-E Circuit Breaker Co., Special Products Div., 601 E. Ernie Ave., Philadelphia, Pa.

Doppler Vor. Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, N.Y.

Jet engine test equipment. George L. Nankervis Co., 15300 Fullerton Ave., Detroit 27, Mich.

Measurement of microphonics. B&K Instruments, Inc., 3055 W. 106 St., Cleveland 11, Ohio.

Microprobe research, a literature list. Instruments Div., Philips Electronics, Inc., 750 S. Fulton Ave., Mt. Vernon, N.Y.

System building blocks. Digital Equipment Corp., Maynard, Mass.

Vibration test studies using the Slip-sync system. Chadwick Helmuth Co., 472 E. Duarte Rd., Monrovia, Calif.

Ultraclean packaged environments. Moore & Hanks Co., Los Angeles, Calif.

Digital instruments catalog no. 19-36. Kintel, A Div. of Cohu Electronics, Inc., San Diego, Calif.

Synchros and rotary components. Clifton Precision Products Co., Inc., Clifton Heights, Pa.

Electromechanical equipment. Hoover Electric Co., 2100 S. Stoner Ave., Los Angeles 25, Calif.

Magnetic tape recorders. Precision Instrument Co., 1011 Commercial St., San Carlos, Calif.

Microline equipment. Sperry Microwave Electronics Co., Div. of Sperry Rand Corp., Clearwater, Fla.

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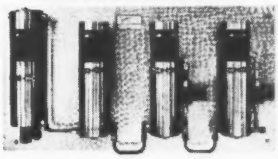
2350 E. 38th St.—Los Angeles 58, Calif.

DEHYDRATION



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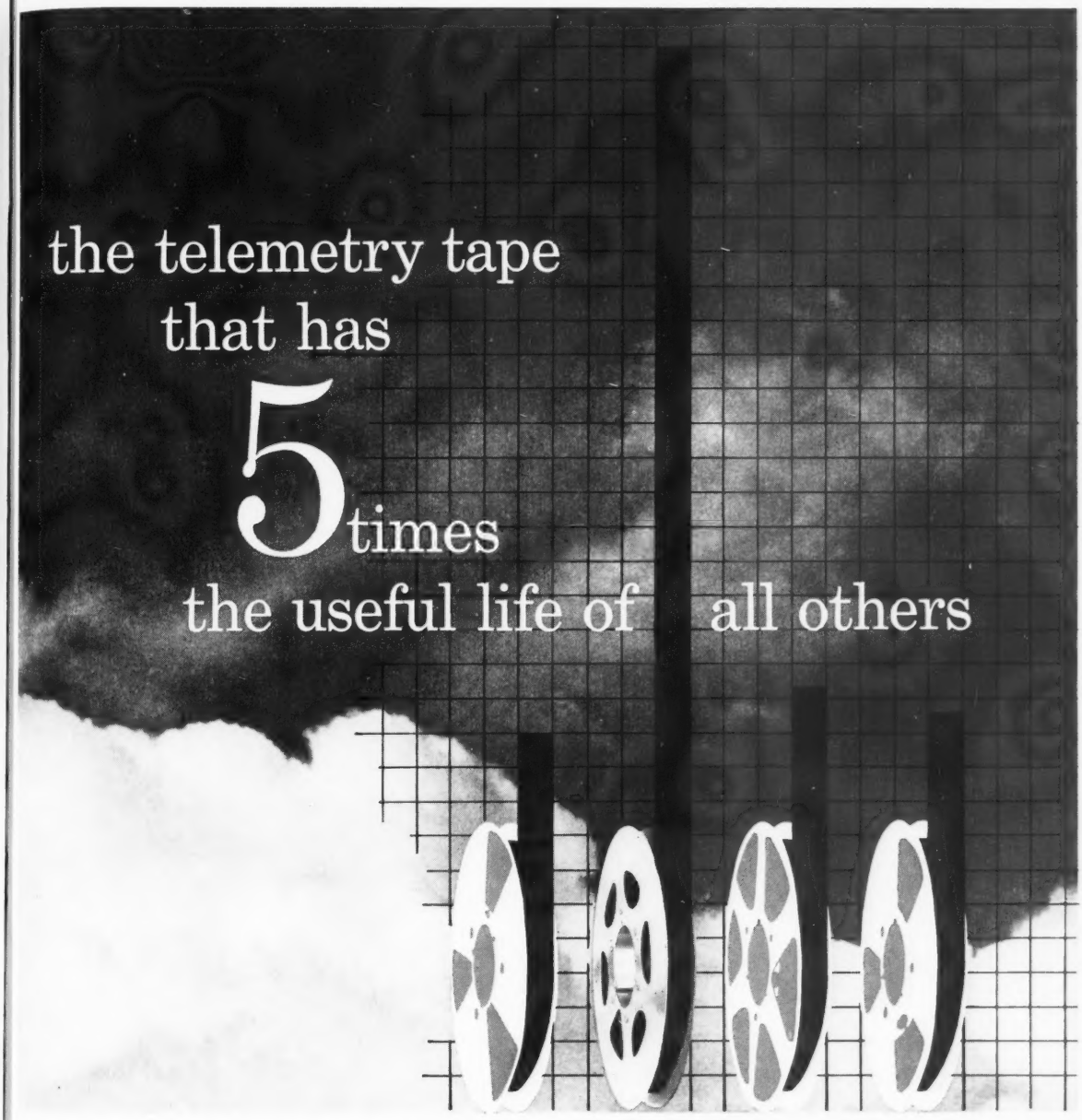

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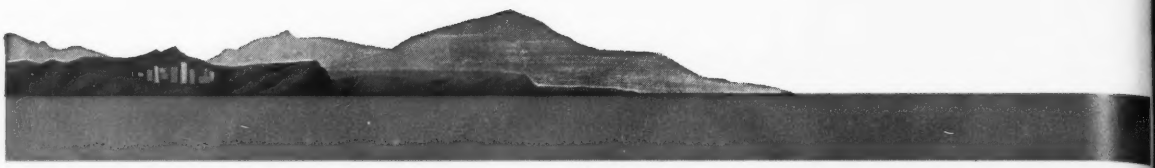

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